Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JANUARY, 1950

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TECHNOLOGY DEPARTMENT

MESTA

FORGED HARDENED STEEL WORKING ROLLS *for Cold Mills*

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FEB 1 - 1950
DETROIT

Finishing a 21" x 98" Mesta Forged Hardened Steel Working Roll, for use in modern high speed Cold Reduction Mills as shown above, in a Mesta 28" Traveling Table Type Roll Grinder.

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

IR v.27 Jan.–June 1950

for the First Time HEAT is LICKED!

In the new line of Cutler-Hammer safety switches, the tables are turned. For here is a switch mechanism designed to withstand *safely* any degree of heat that can be expected from correctly selected fuses.

So dependable in performance, so easy to install, so convenient to operate, so attractive in appearance are these Cutler-Hammer safety switches, alert contractors everywhere are featuring them, recommended by Cutler-Hammer wholesalers from coast to coast. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wisconsin.

CUTLER·HAMMER
SAFETY SWITCHES
C·H

Tech.

IRON AND STEEL ENGINEER, published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 27, No 1.

● **Production**—Increased production of 100% in the smaller pipe sizes due to maximum speed increase from 500 f.p.m. to 1,000 f.p.m.

Cutting—New, continuously running rotary type flying Hot Saw entirely eliminates high maintenance of conventional reciprocating type saws. Cuts to closer tolerances. Operates at twice the speed of hot saws now in use.

Efficiency—Furnace efficiency has been greatly improved. By utilizing wider skelp than in older installations, you have much lower B.T.U. per ton of skelp heated.

Quality—Improved weld by greatly increased reductions in this 12-stand Forming and Welding Mill.

Other Features—1. New Rotary type kickout for high pipe speeds. 2. Hot straightening in line of production. 3. Screw type cooling bed.

Aetna-Standard builds more Continuous Butt Weld Pipe Mills and Seamless Tube Mills than all other companies combined. Ask us about the 12-stand butt weld mill, the newest advance in pipe making.

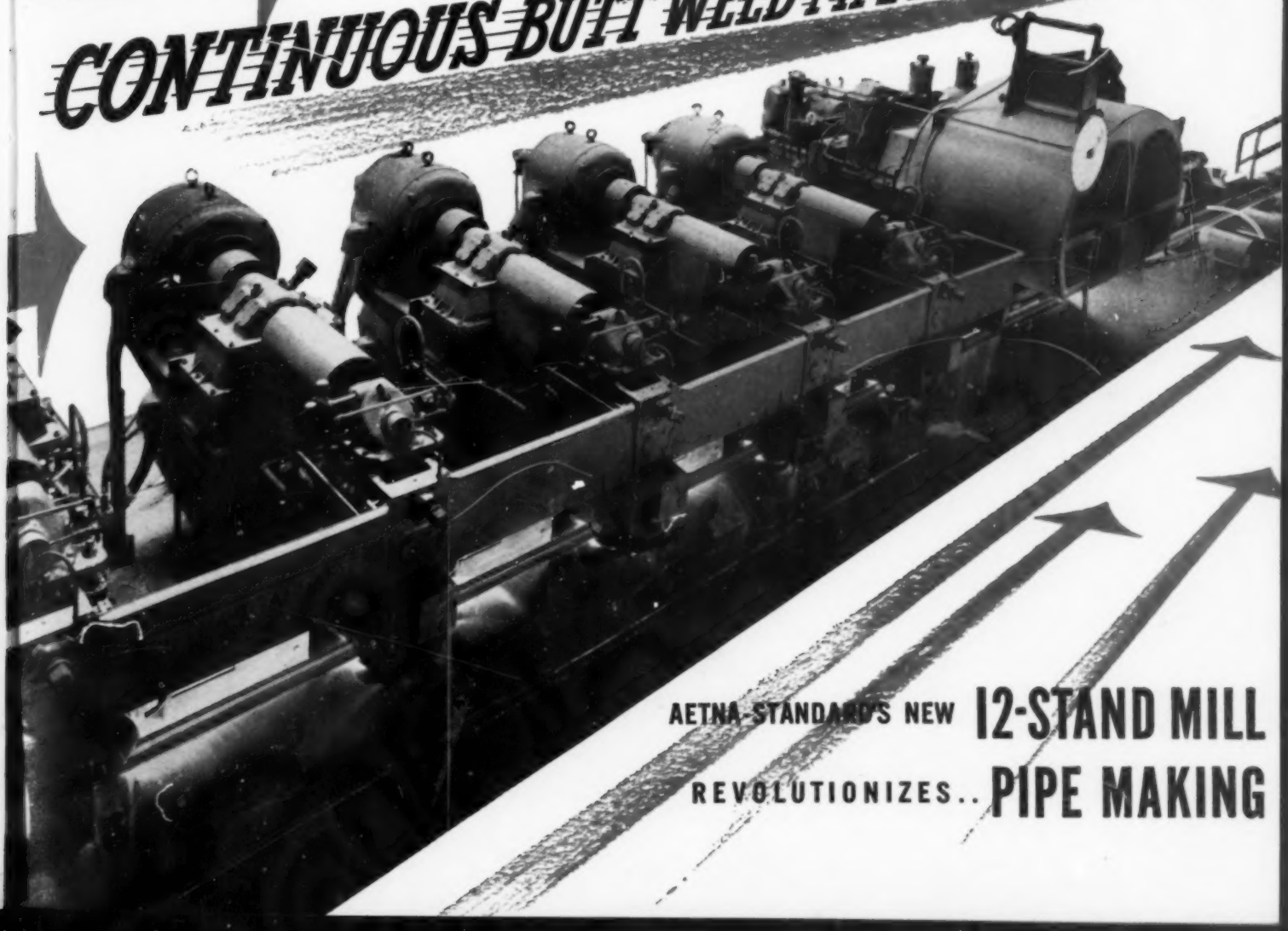
THE AETNA-STANDARD ENGINEERING COMPANY

YOUNGSTOWN, OHIO

ASSOCIATED COMPANIES

AETNA-STANDARD ENGINEERING CO., LTD., TORONTO, ONTARIO, CANADA
HEAD, WRIGHTSON & COMPANY, LTD., THORNABY-ON-TEES, ENGLAND
SOCIETE DE CONSTRUCTIONS DE MONTBARD, 6 RUE DARU, PARIS (8e) FRANCE

CONTINUOUS BUTT WELD PIPE AT 1000 FT. PER MINUTE



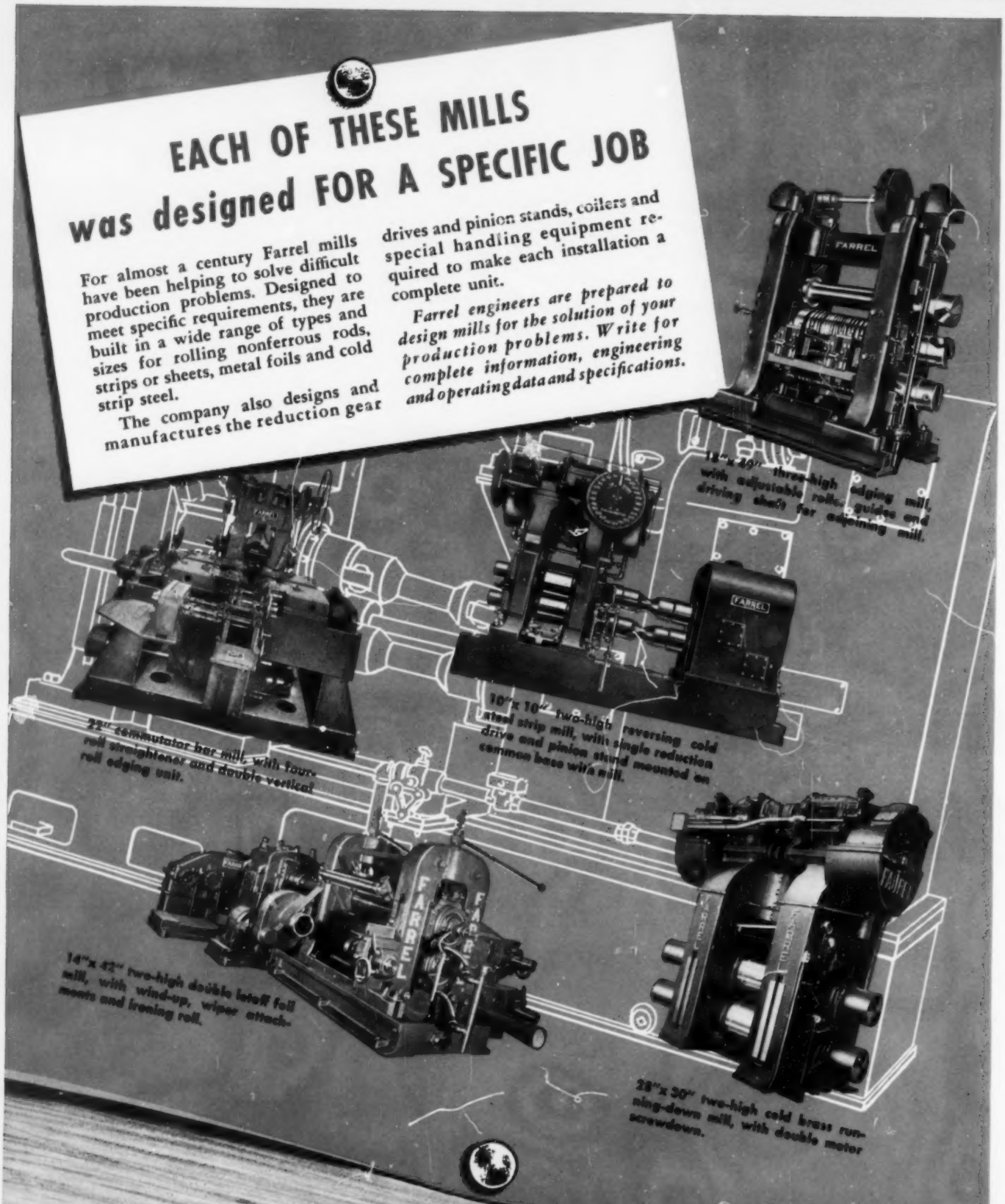
AETNA-STANDARD'S NEW **12-STAND MILL**
REVOLUTIONIZES.. **PIPE MAKING**

EACH OF THESE MILLS was designed FOR A SPECIFIC JOB

For almost a century Farrel mills have been helping to solve difficult production problems. Designed to meet specific requirements, they are built in a wide range of types and sizes for rolling nonferrous rods, strips or sheets, metal foils and cold strip steel.

The company also designs and manufactures the reduction gear drives and pinion stands, coilers and special handling equipment required to make each installation a complete unit.

Farrel engineers are prepared to design mills for the solution of your production problems. Write for complete information, engineering and operating data and specifications.


FARREL
22" commutator bar mill, with four-roll straightener and double vertical roll edging unit.
10" x 10" two-high reversing cold steel strip mill, with single reduction drive and pinion stand mounted on common base with mill.
14" x 42" two-high double letoff foil mill, with wind-up, wiper attachments and ironing roll.
28" x 30" two-high cold brass running-down mill, with double motor screwdown.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.

Sales Offices: Ansonia, Buffalo, New York, Pittsburgh, Akron, Chicago, Los Angeles, Houston

Farrel-Birmingham

FB-547

FREYN-DESIGN BLAST FURNACES OF A DECADE

29 The World Around

FURNACE	HEARTH	LOCATION
1	9'–0"	RHODESIA
2	14'–0"	SO. AFRICA
3	16'–1"	SO. AFRICA
4	18'–0"	ENGLAND
5	18'–3"	SCOTLAND
6	18'–3"	SCOTLAND
7	19'–0"	ENGLAND
8	19'–0"	POLAND
9	20'–0"	ENGLAND
10	20'–0"	ENGLAND
11	20'–0"	ENGLAND
12	20'–0"	SCOTLAND
13	21'–0"	U. S. A.
14	21'–6"	WALES
15	21'–6"	SO. AFRICA
16	21'–6"	SO. AFRICA
17	21'–4"	FRANCE
18	21'–4"	FRANCE
19	21'–4"	FRANCE
20	21'–4"	FRANCE
21	22'–6"	ENGLAND
22	25'–0"	U. S. A.
23	25'–0"	U. S. A.
24	25'–0"	U. S. A.
25	25'–0"	U. S. A.
26	25'–9"	WALES
27	25'–9"	WALES
28	26'–6"	U. S. A.
29	26'–6"	U. S. A.

A WORLD-DOMINANT DESIGN

Most of these blast furnaces were designed and constructed under unified responsibility contracts

Many sizes, in many lands, using many ores.

Freyn Engineering Company

Subsidiary of Koppers Company, Inc.

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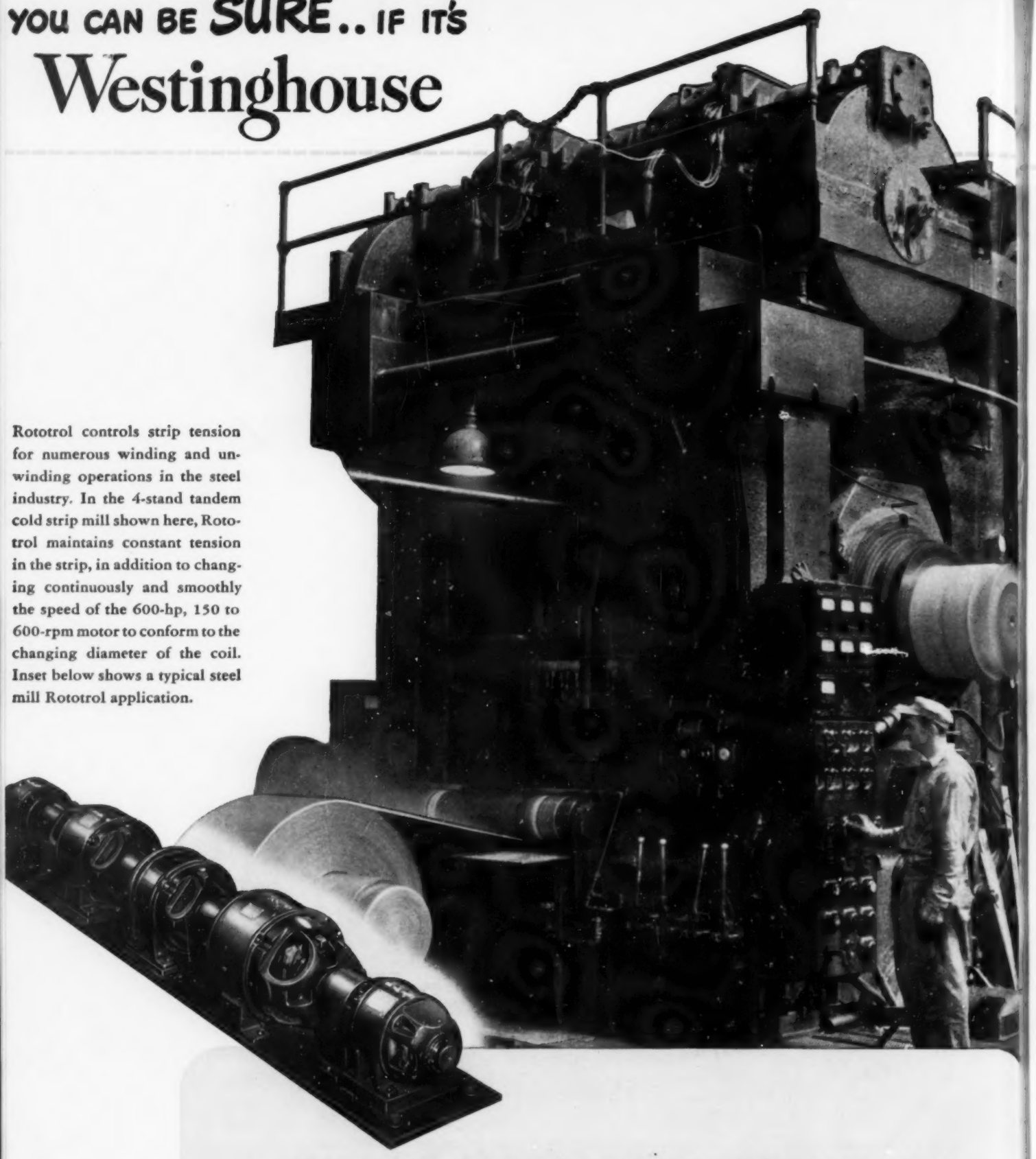
YOU CAN BE **SURE**.. IF IT'S

Westinghouse



Rototrol controls strip tension for numerous winding and unwinding operations in the steel industry. In the 4-stand tandem cold strip mill shown here, Rototrol maintains constant tension in the strip, in addition to changing continuously and smoothly the speed of the 600-hp, 150 to 600-rpm motor to conform to the changing diameter of the coil. Inset below shows a typical steel mill Rototrol application.

INTERACTION OF FIELDS DOES IT ALL

The Westinghouse Rototrol is made exactly like a small, d-c generator, except for several additional field windings. It functions entirely through the smooth interaction of these fields.

Having no mechanical—and very low electrical—inertia, Rototrol responds quickly to deliver the required control power. It brings new standards of perfect performance to almost any repetitive process in the steel industry.

The simplicity of operation makes the Rototrol easy to maintain. It gives unvarying performance indefinitely. It is easily serviced by nontechnical men, and its rugged construction stands up superbly to the rigors of steel mill use.

J-94796

Where else can YOU use ROTOTROL to speed up steel production?

Rototrol—the electrical intelligence—has an outstanding record of accomplishments in the steel industry. By providing smoother, more accurate control of a wide variety of steel processes, it has brought increased production and lower costs.

Here are some of the jobs it is doing:

for skip hoist drives—regulates speed better . . . widens speed range . . . simplifies control.

for blooming mill drives—forces action . . . brings faster, smoother reversals.

for tandem cold strip mills—improves control over stand speeds, acceleration, slowdown and stopping.

for processing lines—matches speed . . . makes possible more rapid acceleration and deceleration . . . minimizes necessary down time.

for flying shear—combined with electronic control, matches speed of shear with that of the mill . . . cuts to close tolerances . . . reduces maintenance costs.

for runout tables and coilers—matches table and coiler speeds accurately with mill speed . . . simplifies operation.

for a-c and d-c generators—regulates voltage . . . holds voltage to preset values . . . returns immediately after changes in loading.

for twin-motor drives—balances load . . . eliminates complex electrical connections.

for rod mills—combined with electronic regulators, matches motor speeds accurately . . . virtually eliminates impact speed drop.

for piercing mill drives—controls stability . . . enables motor to carry high peak loads without pull-out . . . often reduces size and cost of motor needed.

for arc furnaces—regulates power . . . changes electrode position quickly and accurately . . . reduces electrode breakage.

for synchronous motors—regulates voltage automatically . . . adjusts excitation . . . improves power factor.

These applications are suggesting even further uses for Rototrol in the steel industry. There is no foreseeable limit to the improvements possible in steel production methods through better electrical control.

Let Westinghouse applied engineering help you develop and apply new methods and equipment for your specialized requirements. Westinghouse specialists in steel industry applications will be glad to work with your own engineers in studying your operations. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

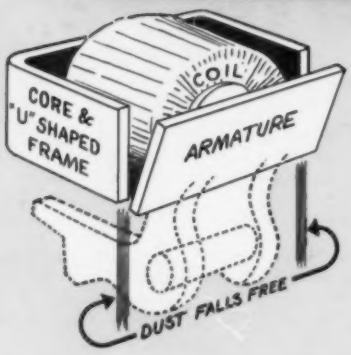
"ROTOTROL IN THE STEEL INDUSTRY"
This 24-page booklet tells the complete story of Rototrol in the steel industry; its functions . . . its applications . . . its remarkable accomplishments as a control for steel-producing machinery. Ask your nearest Westinghouse District Office for a copy of B-3998.

Westinghouse

IMPROVED

EC&M *LINE-ARC* Contactors

CUT OPERATING COSTS

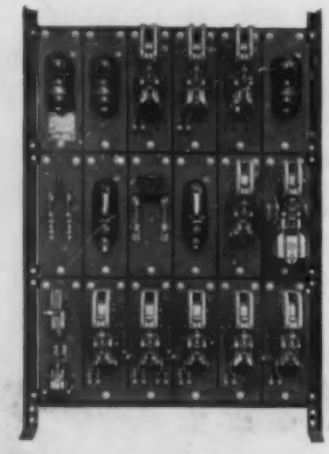


NEW Magnetic Circuit is unrestricted below the air gap

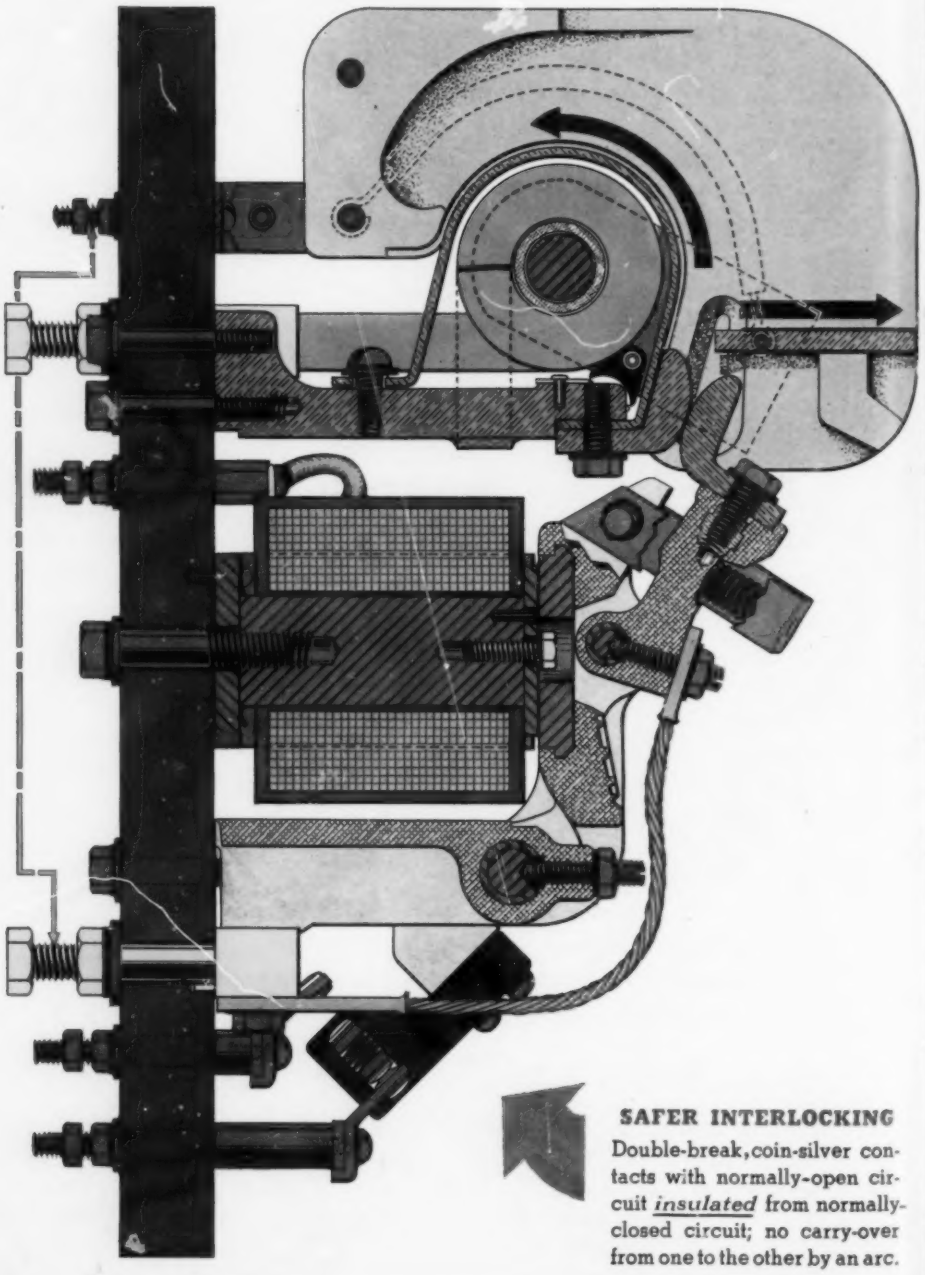
Magnetic dust free to fall. No mechanical shelf to catch it—dust does not pile up in air gap nor pack in, requiring manual removal. EC&M has licked the dust problem.

EC&M *LINE-ARC* Contactors have been improved with a new magnetic circuit and safer electrical interlocks. Remaining unchanged are all current-carrying parts and the well-known EC&M *LINE-ARC* principle, which provides high arc-rupturing ability and long contact life through cool contact operation.

EC&M Contactors of *LINE-ARC* design have a long-standing reputation for efficient operating results. Now, these recently improved contactors give performance far superior to any previous standard of comparison. When buying crane and mill auxiliary controllers—specify EC&M *LINE-ARC* Contactors.



CRANE CONTROLLER



SAFER INTERLOCKING

Double-break, coin-silver contacts with normally-open circuit *insulated* from normally-closed circuit; no carry-over from one to the other by an arc.

THE ELECTRIC CONTROLLER & MFG. CO.

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"All The Way from Design to Erection" is far more than a slogan with Heyl & Patterson. It is a plan of operation wherein each essential function from design to successful operation is performed by the one organization.

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This teamwork permits the successful execution of our contracts for Heavy Bulk Materials Handling Equipment on time and on a basis that brings years of satisfaction to our customers.

It is this teamwork that makes the Heyl & Patterson "TURN-KEY WAY" the most effective way when you want an Ore Bridge or Coal Bridge that includes modern engineering methods with the age-old quality standards that the name "Heyl & Patterson" signifies.

Ore Bridges
Railroad Car Dumpers
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Bradford Breakers
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REELS — Tension

HOUSING PINION — Rolling Mill

TABLES — Blooming Mill • Rolling Mill Feed • Transfer for Mills

LEVELERS — Roller for Plate and Sheet

CCILERS — Ferrous and Non-ferrous Strip

LATHES — Roll Turning

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MACHINES — Pickling

ROLLS — Alloy Iron • Chilled Iron • Sand and Chilled Iron • Steel

Simple Functional Design ...Utmost Efficiency feature all...

LEWIS

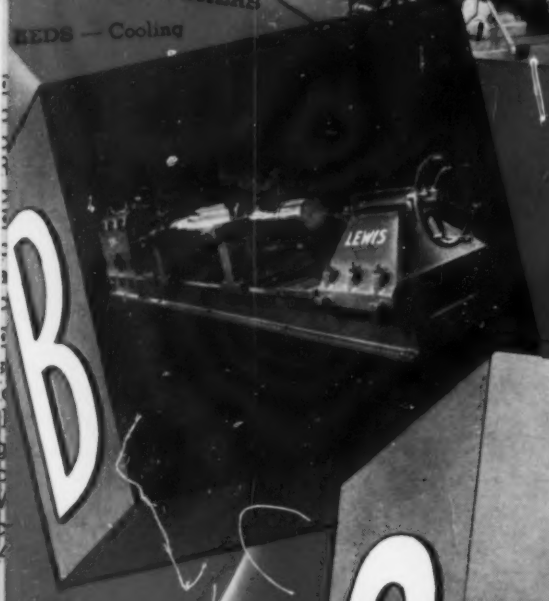
ROLLING MILL EQUIPMENT

LEWIS FOUNDRY & MACHINE

Division of Blaw-Knox Co., Pittsburgh, Pa.

Designers and Builders of Rolls and Rolling Mill Equipment

A



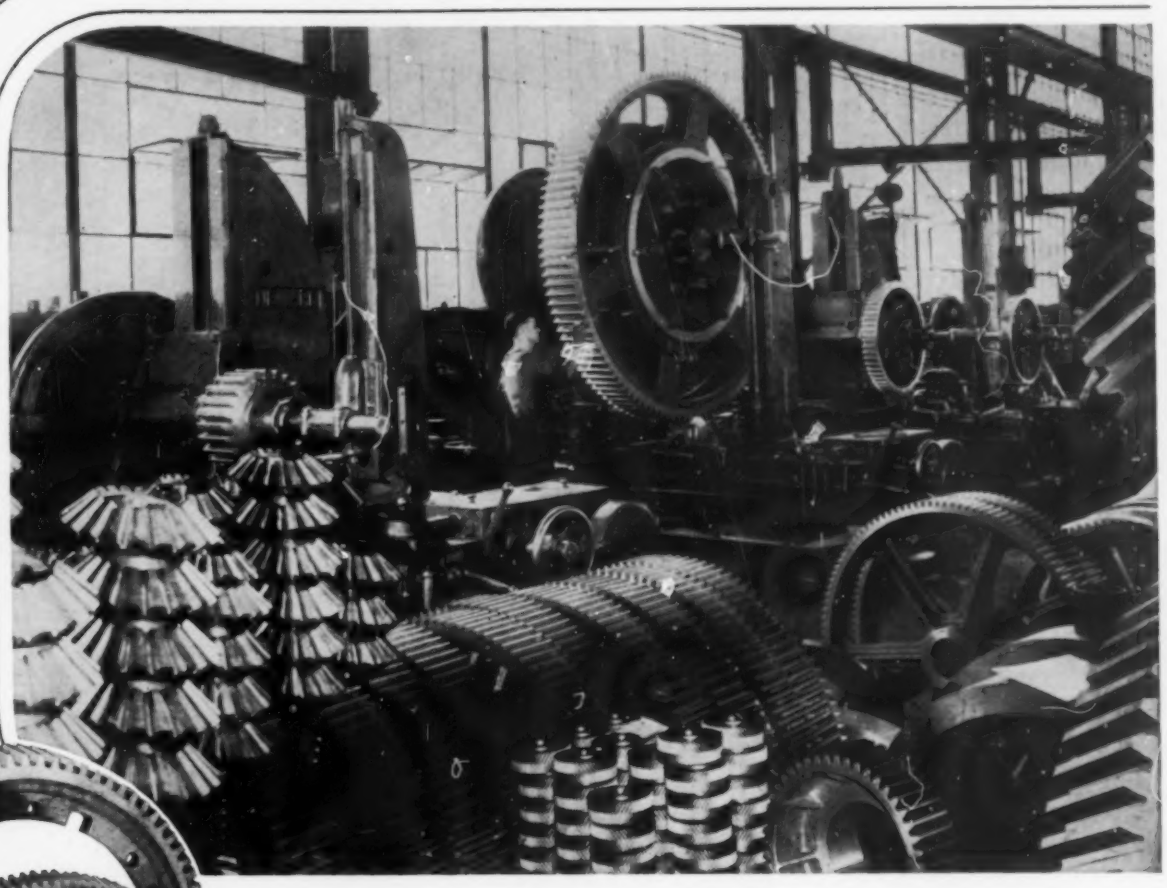
B

C

A
LEWIS 9" and 21" x 44" 4-High Aluminum Foil Mill—Delivery Side

B
LEWIS Roll Lathe

C
LEWIS 26" and 42" x 112" 3-High Balanced Finishing Plate Mill and Tables



GEARS of NELOY and Neloy Molybdenum for a great diversity of Industrial Machines . . .

The requirements for diversified heavy industrial Gear Drives in most types of machines are met with Neloy and Neloy Moly Alloy Gear Steels, furnished complete by National Erie Corporation. Drives for billet shears, high speed presses, forging machinery, over-head traveling cranes, power shovels, draglines, to name only a few classes of heavy industrial machines, require NE Alloy Steels, liquid quenched, because the resistance of these steels to impact is at least three times that of ordinary untreated gears. Desired hardness and increased strength result from a combination of alloying and special hardening carefully controlled by National Erie metallurgists. Gear drives cut from Neloy and Neloy Moly Alloy castings meet with outstanding success. Their long resistance to wear and inherent toughness in rough going are of first importance to builders of heavy industrial production equipment. Write for bulletin No. 9 giving full technical details.

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BOTH CARRY 390 AMPS.

BUT ROCKBESTOS A.V.C.® IS 43% SMALLER

With higher-rated A.V.C. and a 390 ampere load INSTALLED COSTS ARE LOWER*—

- you use a 400 MCM cable *not* 700 MCM
- you use 3″ conduit *not* 3½″
- you use *smaller* fittings and lugs
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Size for size A. V. C. has a HIGHER AMPERE RATING

Hi

. . . YOUR BEST BUY

Permanently-insulated Rockbestos A.V.C. can save you money. Write for the booklet "Cut Current Carrying Costs."

*Comparison with Type RH based on Chapter X—National Electrical Code, 40°C-104°F Ambient

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ROCKBESTOS PRODUCTS CORPORATION
New Haven 4, Connecticut
NEW YORK • CLEVELAND • DETROIT • CHICAGO • PITTSBURGH
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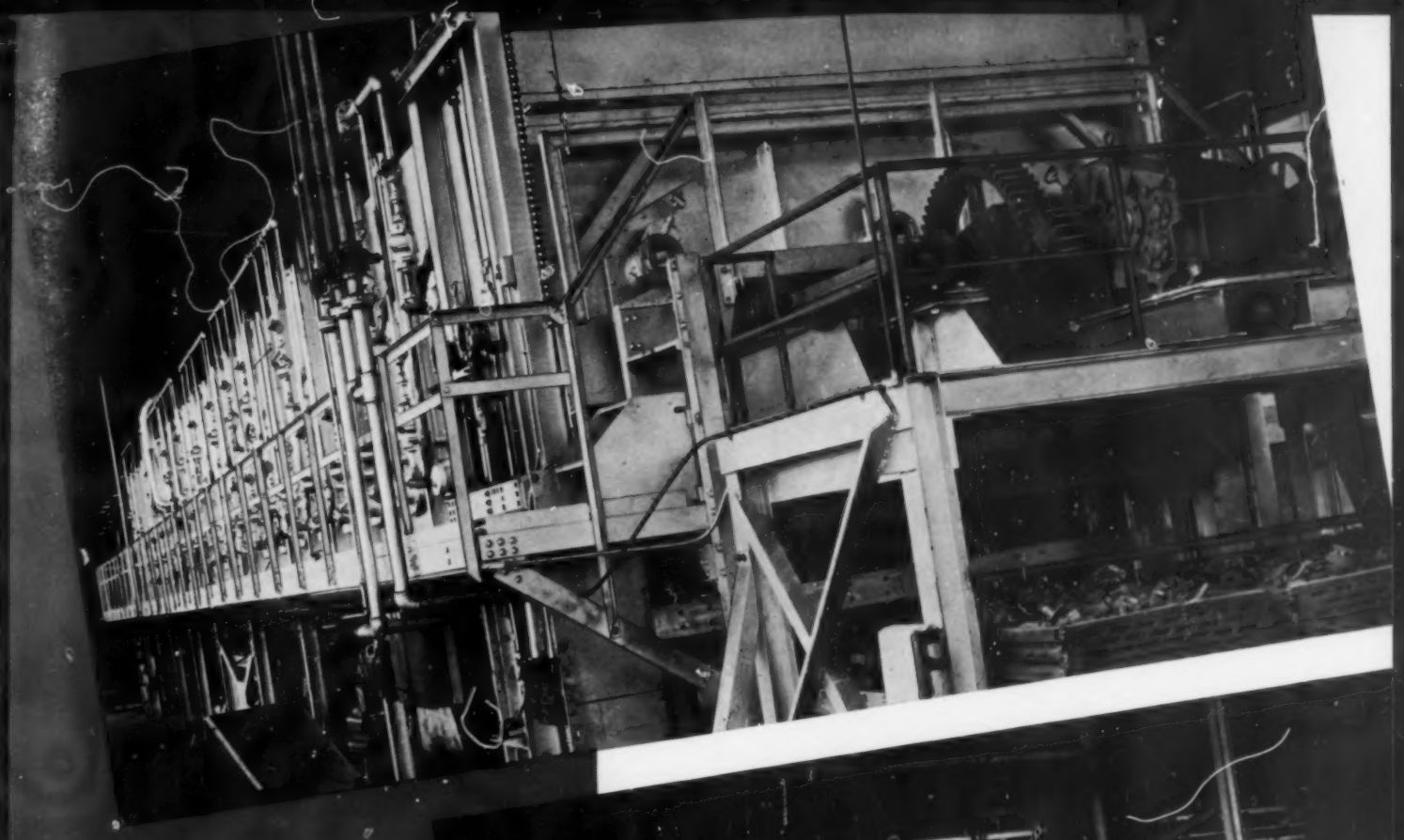

- Continuous atmospheric control
- Precision heat regulation
- Low gas consumption

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Bottom Entry MALLEABLE FURNACES

Swindell Bottom Entry Malleable Furnaces, with specialized design and construction features, provide outstandingly efficient performance in malleable castings production. *May we have your inquiry?*

SWINDELL-DRESSLER *Corporation*

DESIGNERS AND BUILDERS OF MODERN INDUSTRIAL FURNACES

PITTSBURGH, PA.

NEW BAKER FORK TRUCK
Model FT

Costs less to buy— Does more work per dollar— because of its 100% FUNCTIONAL DESIGN

126 INCH TELESCOPING LIFT

64 in. single lift, 63 in. free lift, with 83 in. overall height. Low-pressure hydraulic system for greater safety and lower maintenance.

Specifications

CAPACITY—3,000 and 4,000 pounds.

WIDTH—35 inches.

TURNING—Operates in 64 inch minimum intersecting aisles with 36 inch forks. Outside turning radius 73 inches. Requires only 89½ inches plus length of load for right angle turn.

WEIGHT—with battery—approximately 6,600 pounds for FT-30 (3,000 pounds capacity), 7,500 pounds for FT-40 (4,000 pounds capacity.)

BATTERY—36 V., 400-500 Amp.-hrs.

SPARK ENCLOSED CONSTRUCTION—available at extra cost for safe intermittent operation in gas and dust laden surroundings.

GREATER VISIBILITY

Due to off-center position of operator, cut-away design of dash panel, and construction of uprights and hoist.

OPERATOR CONVENIENCE

Comfortable padded seat and backrest. Entry from either side. Tilted-type automotive steering wheel. Directional, hoist, and tilt control levers to right of wheel. Foot-size accelerator pedal.

UPRIGHT GUIDES

Heavy formed channels welded into a unit assembly. Location of pivot minimizes increase in overall height when tilting. Designed for quick interchangeability on job to uprights of varying heights to permit highway truck or boxcar loading, and extremely high tiering with the same truck.

NO-PLUG CONTROLLER

Drum type, direction selected by manual control, 5 speed foot-operated accelerator. Dead man control. Circuit employed makes plugging impossible.

SOFT-TOUCH BRAKES

Air-cooled drum type, mechanical. Mounted on motor shaft for braking through gear train and differential, providing equalizing action. Dynamic braking in varying degree obtained by reversing controller and advancing accelerator.

CUSHION TIRES

Provide a softer ride, longer wear, high power efficiency and greater traction.

WORM DRIVE AXLE

Exclusive rugged and simple design for maximum efficiency and long life.

BAKER-BUILT MOTORS

Travel and auxiliary motors designed by Baker especially for industrial truck application.

WIDE ANGLE STEER

Heavy-duty, automotive type shock-proof steer with proper geometry to prevent scrubbing of tires. Knuckle-type axle with rubber-mounted longitudinal pivot provides compensation for uneven roadways.

ALL-STEEL FRAME

Heavy gauge, unit-welded with integral hydraulic tank. Steel plate bumper providing effective counterweight, welded integral with frame for greater rigidity and strength.

Learn How Little This Truck Costs!

Write for full descriptive data and prices and see for yourself why the Baker FT costs less to buy and does more work per dollar because of its 100% functional design.

BAKER INDUSTRIAL TRUCK DIVISION

of The Baker-Raulang Company

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SQUARE D's *New*

SAFETY SWITCHES

*Types A, C and D

Backed by 40 years' DESIGN LEADERSHIP

The remarkable superiority of this new switch line is reflected in these TYPE A design and operating features:

MODERN STYLING is both functional and attractive.

COMPACTNESS obtained without sacrifice of wiring convenience.

FULL COVER INTERLOCK has attachment that locks switch "ON" or "OFF" with 1, 2, 3 or 4 padlocks of nearly any size or shape.

SIMPLE MECHANISM—quick make-and-break action—no dead center.

SILVER-PLATED current-carrying parts.

EXPOSED BLADES permit visual checks of switch operation.

DEAD-FRONT line terminals are protected by hinged arc chamber cover.

MAGNETIC ARC PLATE adds to unusually high rupturing capacity.

POSITIVE PRESSURE jaws and fuse clips, steel reinforced, silver-plated.

NON-TRACKING insulation used in base. Melamine insulating cross-bar.

REMOVABLE PRESSURE CONNECTORS permit substitution of solder lugs, where preferred.

Types C and D* *similar to Type* **A *in appearance—differ in construction details*

NOW in production: 30, 60, 100 and 200 ampere sizes

Write **for Bulletin 3100 • Square D Company, 6060 Rivard Street, Detroit 11, Michigan**

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Loading up...FOR A 40% SAVING

CUT UP TO $200,000 A YEAR FROM REFUSE DISPOSAL COSTS

From Open Hearth to Dump and back again. That can be a costly operation or just a normal operating expense.

It all depends on the equipment used.

Gondola, hopper or obsolete air dump cars run the cost of refuse disposal way up out of sight. They're not built for the job. The heat of lading and banging of buckets makes maintenance and repair quite a sizeable item on your annual budget. On top of that, there's added labor costs, loss of operating time and haulage waste due to inefficient equipment.

Here's how you can bring those costs down within reach and maintain an even higher degree of operating efficiency – New Magor Air Dump Cars – built specifically for steel plant service.

New Magor Air Dump Cars are a modern low-cost approach to refuse disposal. They can take the roughest treatment year in and year out with a minimum of maintenance expense. Through labor and maintenance savings alone, you can write off your entire investment within a few years.

COST LESS THAN $1.35 A DAY

That's all it costs to own a 30 yd. 70 ton Heavy Duty Steel Plant Magor Air Dump Car – *dump cars that can cut your refuse disposal costs as much as 40%.*

The New **MAGOR** *Steel Plant Air Dump Car*

Write today for your copy of the new brochure, "The Answer to High Refuse Disposal Costs." This well-illustrated brochure explains, in detail, the many money-saving advantages of owning Magor Air Dump Cars.

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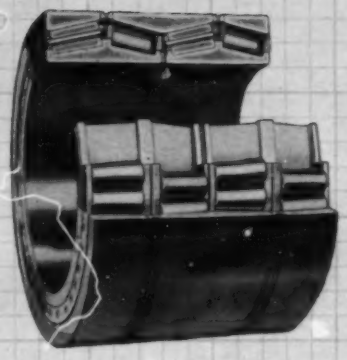
TORRINGTON ROLL NECK BEARINGS

for greater rigidity in Jones & Laughlin mill



Jones & Laughlin Steel Corporation's mile-a-minute cold strip mill (world's fastest) at Aliquippa incorporates the most advanced engineering experience.

A factor contributing to the mill's great rigidity—vital in securing rapid and accurate reduction of steel strip—is the use of Torrington Tapered Roll Neck Bearings specially engineered for use on work rolls.

These bearings accommodate larger roll neck diameters owing to their reduced cross-section, yet provide extra capacity to handle tremendous thrust and radial loads. High quality production and important operating economies are assured by this Torrington Roll Neck Bearing feature. For anti-friction bearings specially engineered to the design and service requirements of your application, call on Torrington.

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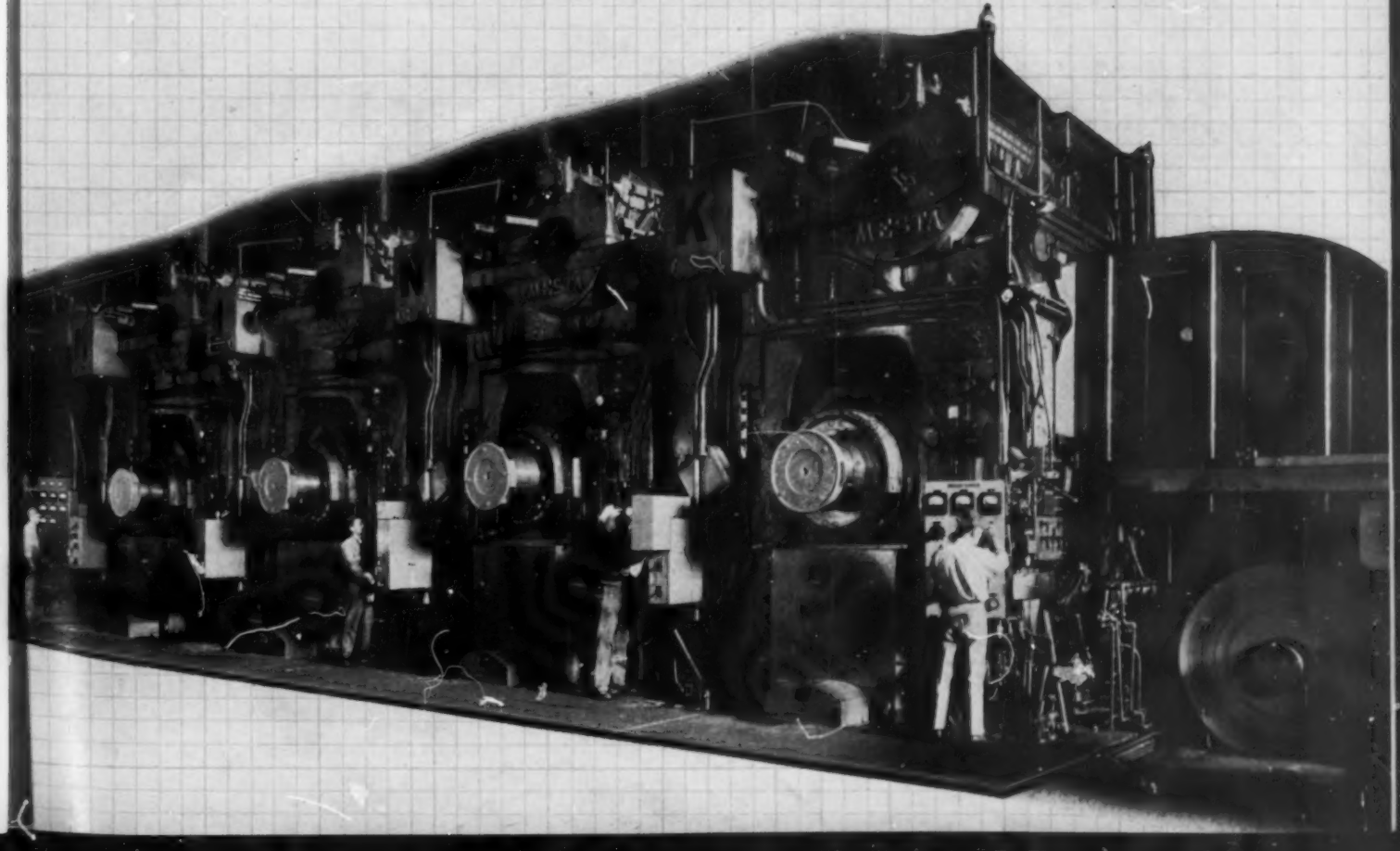
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON *TAPERED ROLLER* **BEARINGS**

SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • NEEDLE • BALL • NEEDLE ROLLERS



Speer carbon brushes are especially designed to withstand the exacting demands of electric hoist motors. This means the ability to meet the high starting torque and frequent reversals necessary for full load performance.

By matching brushes to service characteristics, Speer has provided during the past 50 years, a complete line of brushes to meet all motor and generator requirements. Complete experimental and testing facilities are available for analyzing your brush requirements for machine designs or maintenance problems.

5922

Speer

CARBON COMPANY
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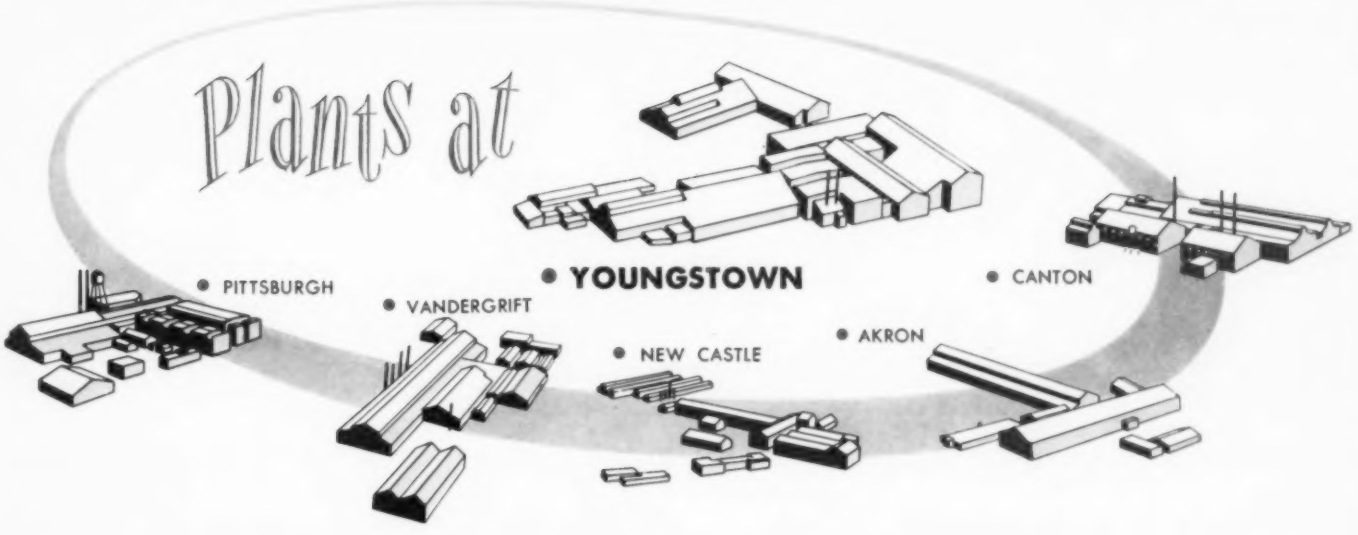
brushes · contacts · welding electrodes · graphite anodes · rheostat discs · packing rings · carbon parts

CHICAGO · CLEVELAND · DETROIT · MILWAUKEE · NEW YORK · PITTSBURGH

View of erection floor, Youngstown, Ohio plant



UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

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Designers and Makers of Rolls and Rolling Mill Equipment

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OOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

SLAB TURNING GANTRIES

When your Slab Turning Gantries are "Shaw-Box," you get all the advantages of outstanding engineering and construction excellence for which "Shaw-Box" Steel Mill Cranes are known throughout the industry — plus proven safeguards to prevent damage to the Gantry.

Slab Turning Gantries have long been a "Shaw-Box" specialty, and are built to perform under the most severe operating conditions with a minimum of maintenance attention and expense. They fully conform to AISE specifications. Outstanding mechanical advantages include a perfected ratchet device that disengages the hoisting mechanism if load is carelessly handled, eliminating the possibility of raising the trolley off bridge when engaging loads. Ram may be removed without disturbing the operating mechanism. Roller guides prevent swing of mast and guide the rams.

"Shaw-Box" Slab Turning Gantries today offer the greatest value for every dollar invested.

Be sure to send all your inquiries and specifications for Slab Turning Gantries and Steel Mill Cranes to "Shaw-Box."

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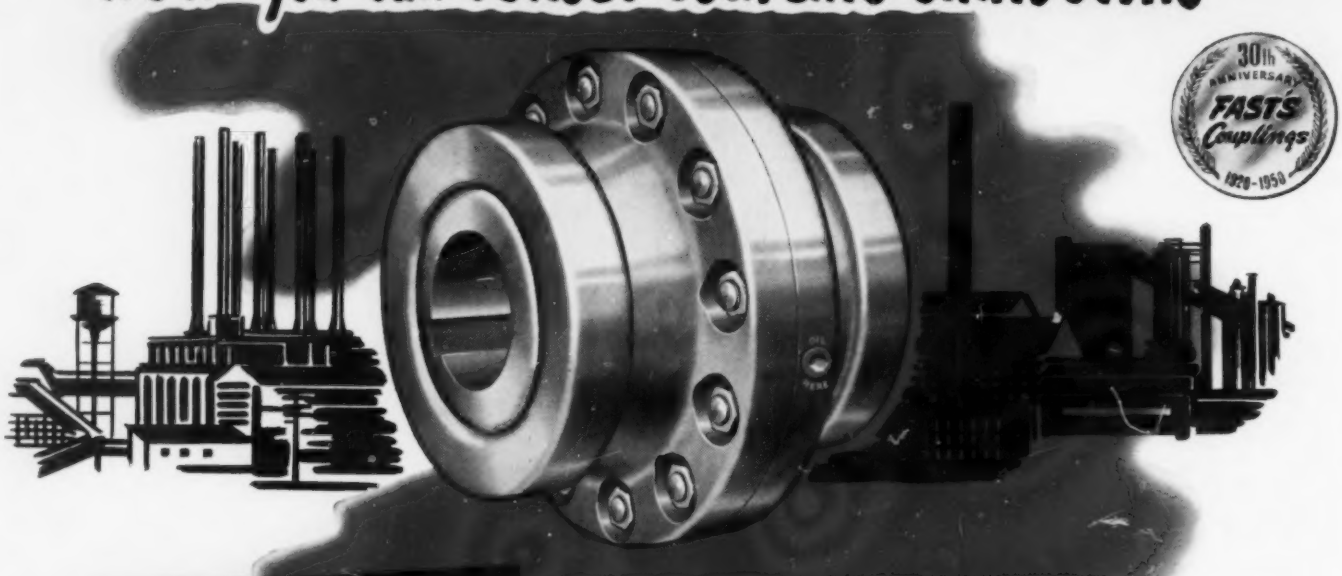

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In oil fields, steel mills, power plants . . . all through industry . . . cost-wise executives report that *Fast's Couplings,* designed, manufactured and guaranteed by Koppers, are the best insurance against coupling failures! Take a tip from these users who know. Specify Fast's and forget *your* coupling problems!

By specifying Fast's, you get the benefit of Koppers Engineering Service, acknowledged best in the industry. Koppers Engineers, backed by 30 years coupling experience, study your problem . . . then show you *which* Fast's Coupling fits your application, (and more important) *why* you need it!

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UNSURPASSED ENGINEERING . . . *Koppers Engineers are acknowledged the best in the coupling industry. Their practical knowledge, backed by 30 years of coupling experience, is at your service!*

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THE ORIGINAL GEAR-TYPE

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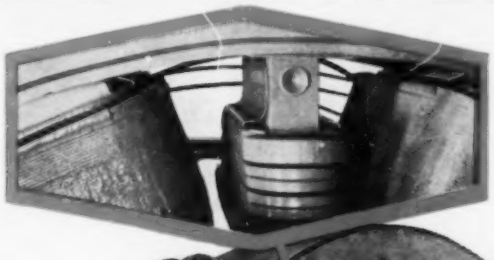
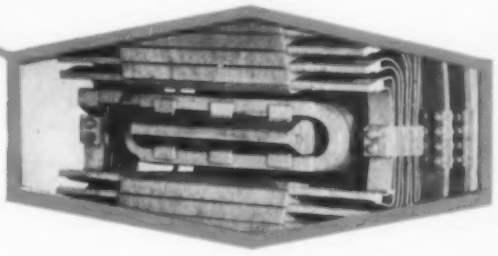
Elliott STEEL DC Motors stay on the job . .

...built with carefully planned rugged construction of each part, enabling them to stay in service without costly and time-consuming repairs.



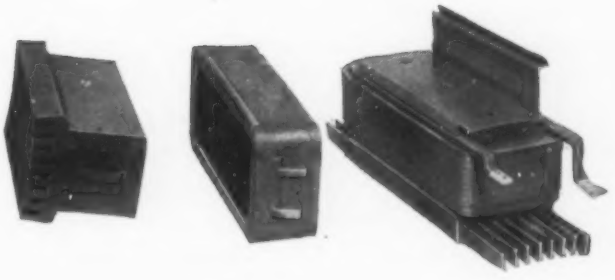
Coil tighteners compressed between the frame and coils.

FIELD FRAME—Coils and windings readily accessible for cleaning or maintenance, yet rigidly braced against movement and chafing without resort to the use of cording or wood blocking which deteriorates with age; fully compensated rectangular type bar winding with joints silver-alloy brazed; thick, split frame, of minimum length, gives unusual stiffness and allows better cooling and access to field windings.



Non-magnetic steel fingers welded to commutating pole piece.

MAIN FIELD POLE, COILS, AND COIL TIGHTENERS—Pole insulation built into shunt coil from inside and folded over outside of coil at top and bottom and anchored by turning it under last layer of conductors; top and bottom corners of coils, where not covered by pole insulation, protected with mica corner pieces extending under pole insulation; radial and side movement of coil prevented by pressure of corrugated steel coil tighteners between frame and pole; steel spacers welded to pole ends prevent axial movement.



COMMUTATING FIELD POLE, COIL, AND COIL TIGHTENERS– Conductors insulated from pole by U-shaped channels inserted over each turn from inside coil; canvas phenolic strips taped to top and bottom of coil; radial, axial and side movement of coil prevented by pressure of corrugated steel coil tighteners between frame and non-magnetic fingers welded to inner end of pole piece.

For full details write to DEPT. I-S.

MR-3

ELLIOTT COMPANY Ridgway Division, **RIDGWAY, PA.**

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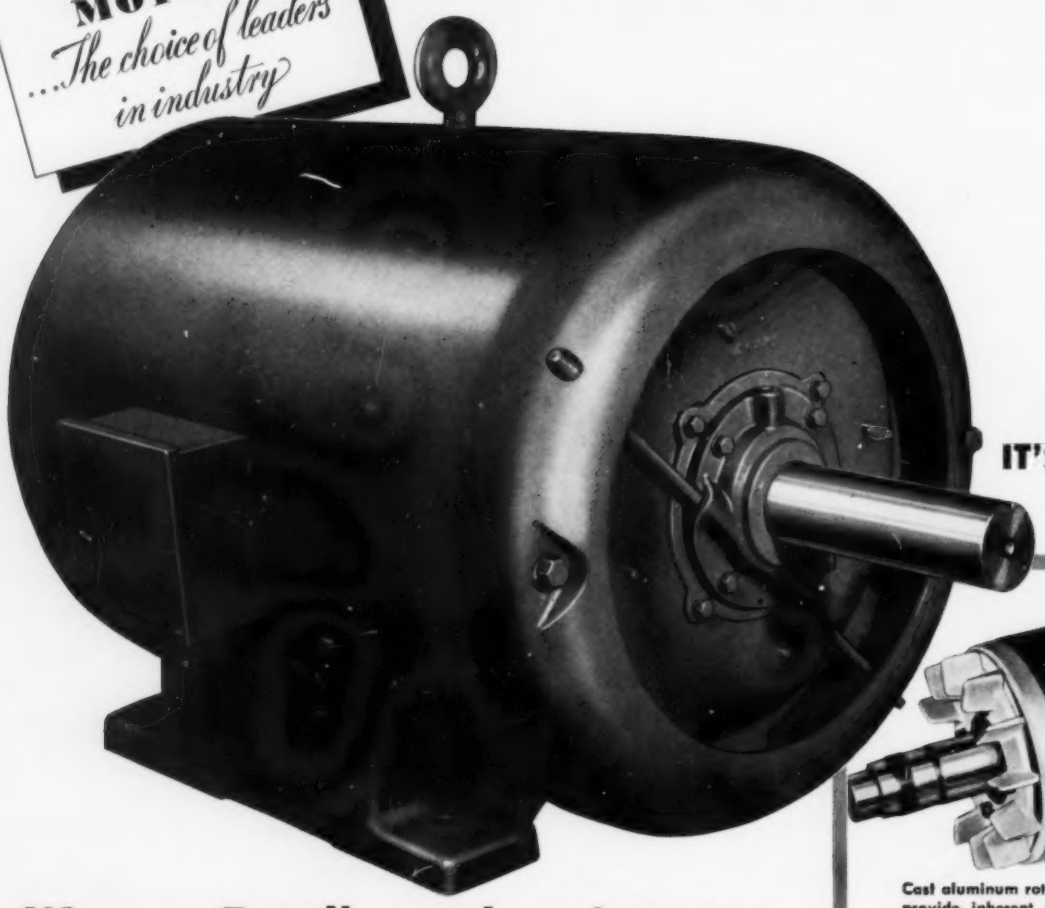
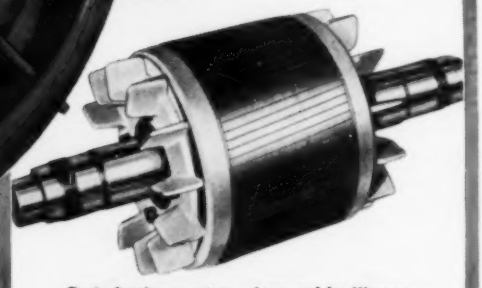
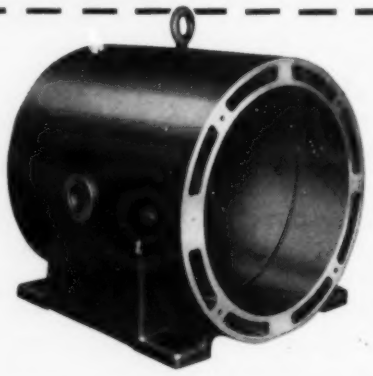
WAGNER MOTORS
...The choice of leaders in industry



IT'S WAGNER *because:*



Cast aluminum rotors, pioneered by Wagner, provide inherent mechanical and electrical characteristics that add quality and dependability to Wagner type CP Motors.



The rugged frame, used on Wagner type CP Motors, has extra large air ducts around the entire stator to prevent clogging and to permit plenty of fan-driven air to cool the motor.

Wagner Totally-enclosed Motors *best* for really dirty jobs!

Wagner totally-enclosed fan-cooled motors are designed for a particular purpose—to operate efficiently and safely under conditions that would quickly damage an ordinary open type motor. In really dirty jobs—in atmospheres filled with dust, fumes, moisture, abrasives, steel chips and other harmful elements—these *protected* Type CP Motors keep on working, delivering dependable power with no maintenance other than periodic lubrication. Wagner totally-enclosed fan-cooled motors are varied electrically to suit a wide variety of application requirements.

Bulletin MU-185 gives complete information on Wagner Motors. Twenty-nine sales and service branches, in principal cities, are ready to help you on any motor problem. In addition, almost 500 authorized motor repair shops provide speedy, nationwide service facilities.

Wagner Electric Corporation
EST. 1891

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6483 Plymouth Ave., St. Louis 14, Mo., U.S.A.

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WITH THE NEW BROWN PROPORTIONAL CONTROL RELAY

HERE'S a combination that's hard to beat . . . the extreme sensitivity of the famous *ElectroniK* Strip-Chart Controller used to its fullest advantage with the amazing versatility of a truly modern proportional relay. Their proper use is a sure way to get the most out of your process.

Check these extra features of this new, compact relay!

- *Unmatched sensitivity and stability.*
- *Positive action.*
- *Manual reset adjustment.*
- *Signal lights to indicate fuel valve operation.*
- *Adjustment of 24% to 206% of the nominal proportional band value of the potentiometer's resistor.*
- *Designed for flush mounting.*
- *Drawer-type construction makes it easily accessible.*

It may also be used with the *ElectroniK* Circular Chart Controller . . . is available for any proportioning control installation.

Call in your local Honeywell engineer for a discussion of how this winning combination can add up dollar and cents savings for you . . . he is as near as your phone!

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Wellman Coke Pushers

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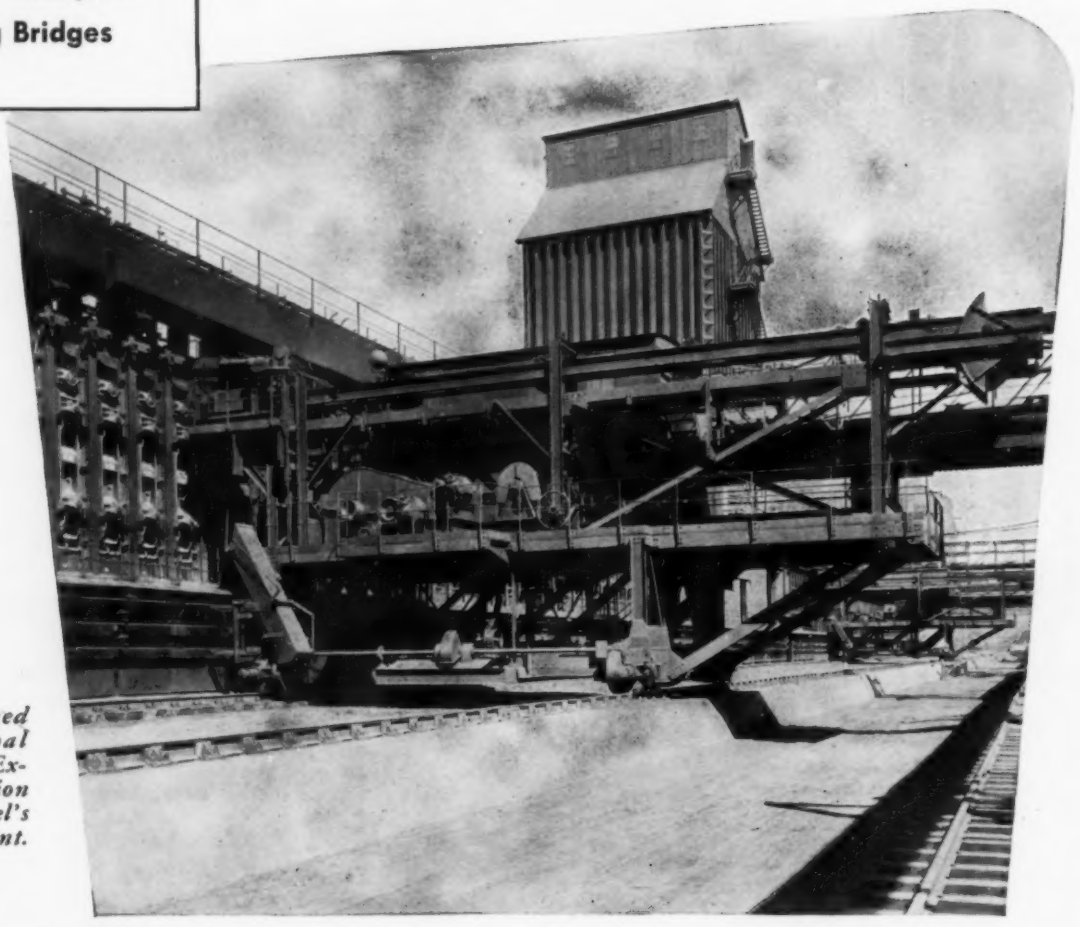

Wellman Combined Coke Pusher, Coal Leveler and Door Extractor in operation at Bethlehem Steel's Lackawanna Plant.

● Many of the world's most modern byproduct coke oven plants are Wellman equipped. The Wellman Engineering Company's more than half-century experience in building heavy machinery guarantees sound design and expert construction. Wellman equipment provides peak economy, maximum safety and trouble-free performance under a wide variety of operating conditions. For conservative, reliable recommendations on your heavy equipment, phone or write:

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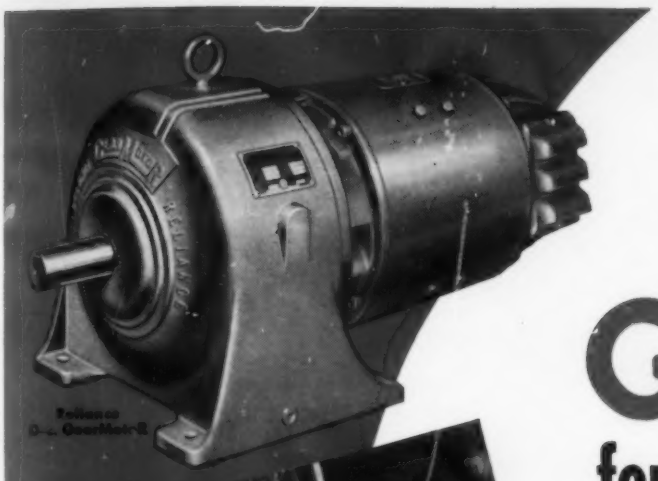

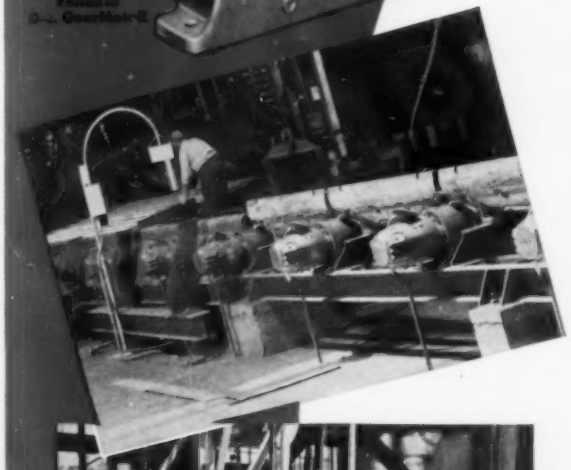

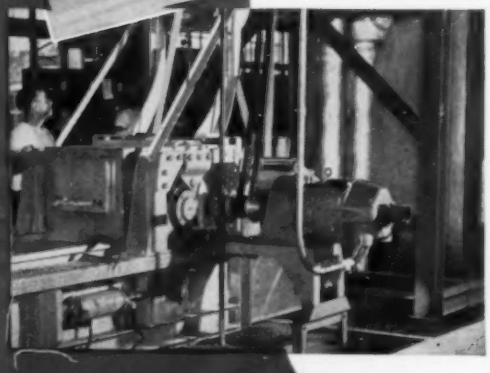

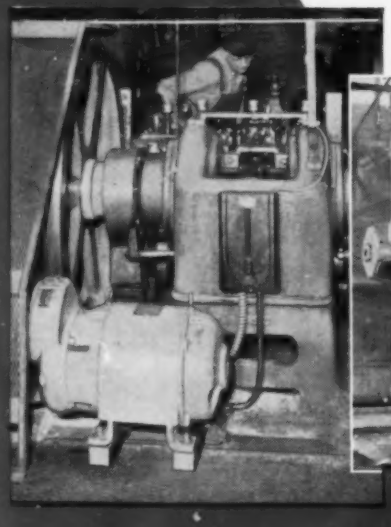

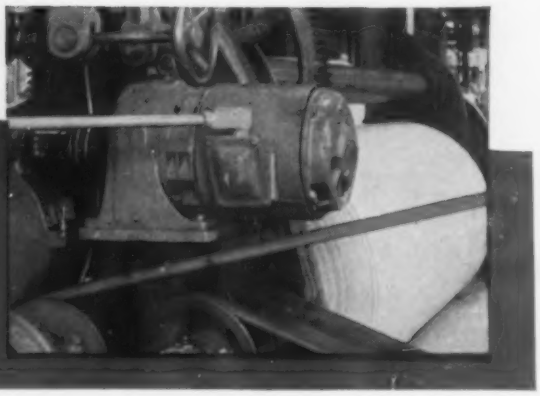

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It's the

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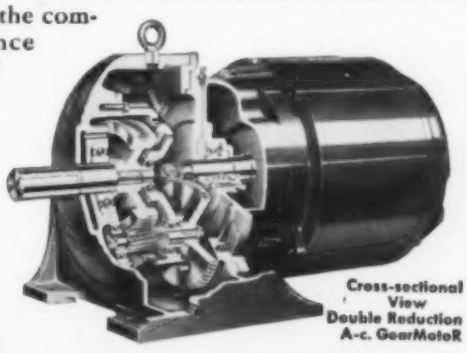
for outstanding performance

Of the many design and construction features which have distinguished the performance of Reliance GearMotoRs in every type of application in every industry, here are some which should interest you:

1. Helical, wear-hardened gears cut from alloy steel forgings and shaved before hardening for correct eccentricity and helical angle and bright, smooth surfaces—factors contributing to quiet operation and longer life.
2. Gear arrangement in simple train minimizes number of moving parts—promotes quietness.
3. Pinion and gear supported and spaced to reduce deflection—permits high load-carrying capacity.
4. Splash system with large oil reservoir assures constant and thorough lubrication of all parts.
5. Anti-friction bearing construction throughout.
6. Reliance *Precision-Built* Motors provide the maximum in dependable and economical power.

For facts on other proved-in-service advantages of Reliance GearMotoRs, write for Bulletin C-404. Ask at the same time for bulletins describing the complete line of Reliance PRECISION-BUILT Motors.



Cross-sectional View Double Reduction A-c. GearMotoR

RELIANCE ELECTRIC AND ENGINEERING CO.

1084 Ivanhoe Road, Cleveland 10, Ohio • *Sales Representatives in Principal Cities*

Cranes Built to AISE

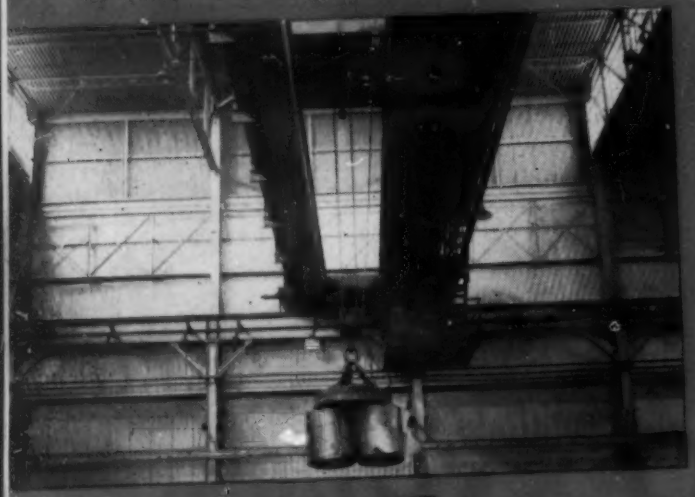
Cleveland Steel Mill Cranes Meet or Exceed *ALL* AISE Specifications

● For many years Cleveland Crane has worked closely with the Association of Iron and Steel Engineers and the Steel Industry in the drafting of overhead crane specifications that adequately cover the hard requirements necessary for proper mill performance.

Cleveland knows the "specs" and designs mill cranes in accordance with them. All Cleveland mill-type cranes meet or exceed AISE Specifications for Electric Overhead Traveling Cranes for Steel Mill Service.

THE CLEVELAND CRANE & ENGINEERING CO.
1131 EAST 289TH ST. WICKLIFFE, OHIO

10 Ton, 100'-0" Span Magnet Crane



Four 15 Ton, 120'-0" Span Cranes

SOME OF THE MILLS BEING SERVED BY CLEVELAND ALL-WELDED MILL-TYPE CRANES

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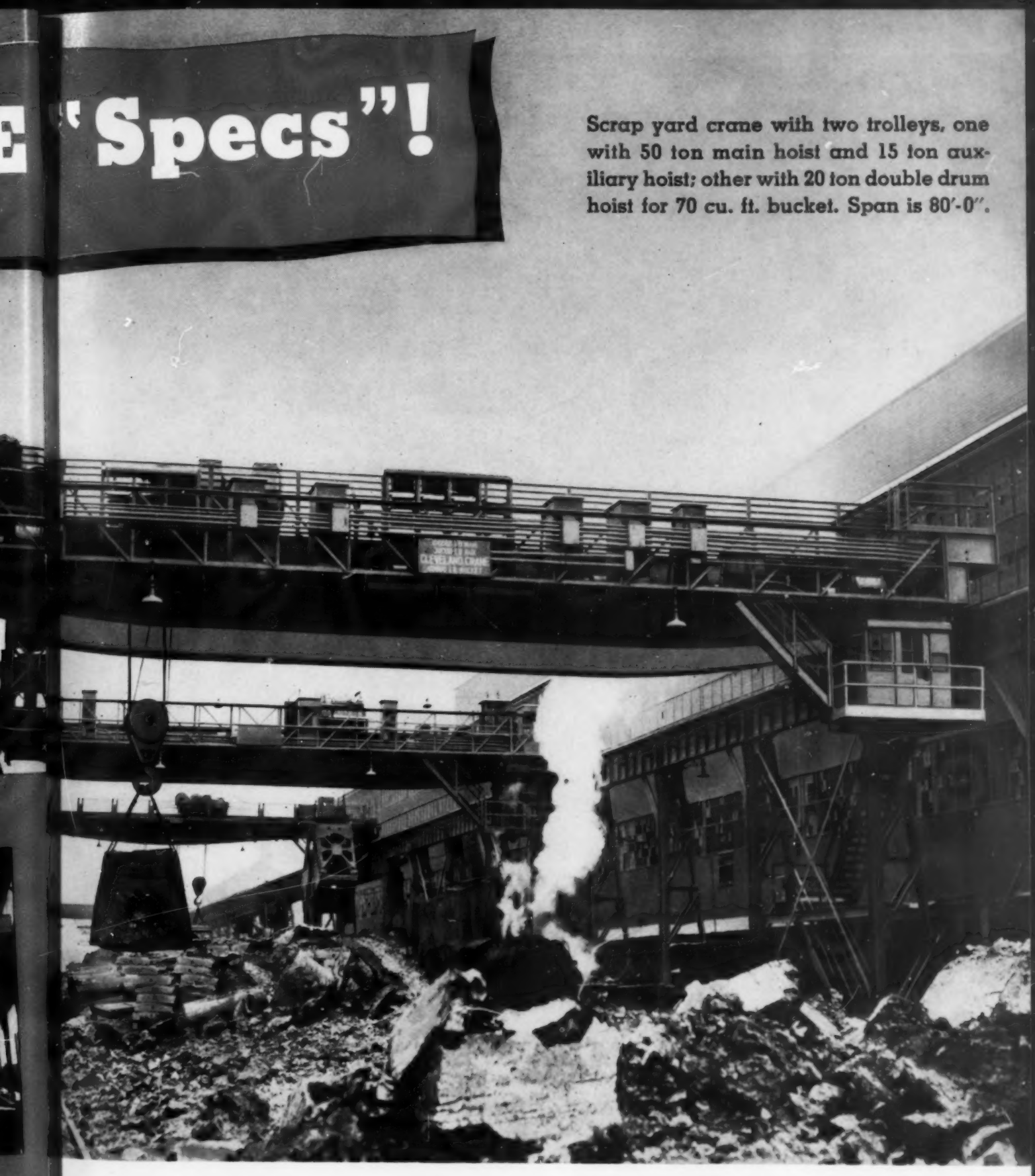
Weirton Steel Company
Wheeling Steel Corporation
The Colorado Fuel and Iron Corporation

E "Specs"!

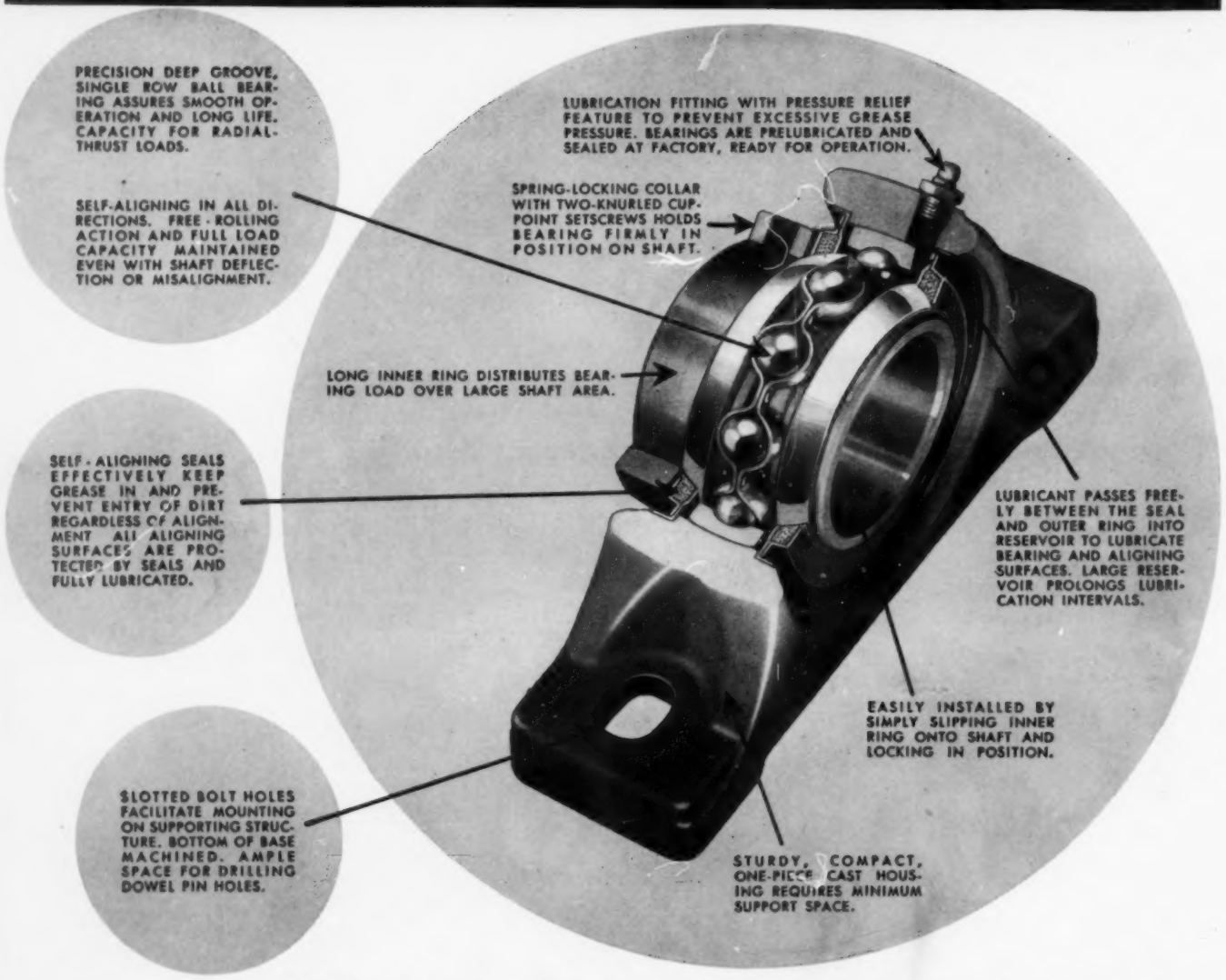
Scrap yard crane with two trolleys, one with 50 ton main hoist and 15 ton auxiliary hoist; other with 20 ton double drum hoist for 70 cu. ft. bucket. Span is 80'-0".



CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

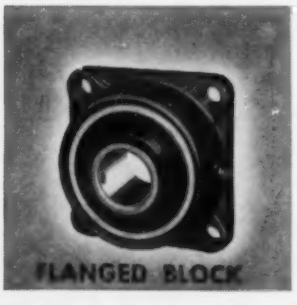
PLUS VALUES in Series 200 LINK-BELT *Ball Bearing* BLOCKS

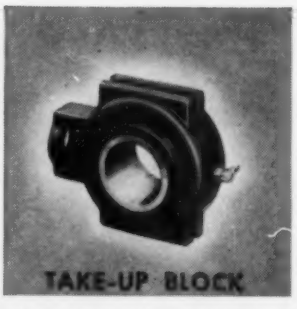

PRECISION DEEP GROOVE, SINGLE ROW BALL BEARING ASSURES SMOOTH OPERATION AND LONG LIFE. CAPACITY FOR RADIAL-THRUST LOADS.
SELF-ALIGNING IN ALL DIRECTIONS. FREE-ROLLING ACTION AND FULL LOAD CAPACITY MAINTAINED EVEN WITH SHAFT DEFLECTION OR MISALIGNMENT.
SELF-ALIGNING SEALS EFFECTIVELY KEEP GREASE IN AND PREVENT ENTRY OF DIRT REGARDLESS OF ALIGNMENT. ALL ALIGNING SURFACES ARE PROTECTED BY SEALS AND FULLY LUBRICATED.
SLOTTED BOLT HOLES FACILITATE MOUNTING ON SUPPORTING STRUCTURE. BOTTOM OF BASE MACHINED. AMPLE SPACE FOR DRILLING DOWEL PIN HOLES.
LUBRICATION FITTING WITH PRESSURE RELIEF FEATURE TO PREVENT EXCESSIVE GREASE PRESSURE. BEARINGS ARE PRELUBRICATED AND SEALED AT FACTORY, READY FOR OPERATION.
SPRING-LOCKING COLLAR WITH TWO-KNURLED CUP-POINT SETSCREWS HOLDS BEARING FIRMLY IN POSITION ON SHAFT.
LONG INNER RING DISTRIBUTES BEARING LOAD OVER LARGE SHAFT AREA.
LUBRICANT PASSES FREELY BETWEEN THE SEAL AND OUTER RING INTO RESERVOIR TO LUBRICATE BEARING AND ALIGNING SURFACES. LARGE RESERVOIR PROLONGS LUBRICATION INTERVALS.
EASILY INSTALLED BY SIMPLY SLIPPING INNER RING ONTO SHAFT AND LOCKING IN POSITION.
STURDY, COMPACT, ONE-PIECE CAST HOUSING REQUIRES MINIMUM SUPPORT SPACE.

Send for Catalog No. 2550

Highlighted above are several of the PLUS VALUES built into Series 200 Link-Belt Ball Bearing Pillow Blocks. No wonder bearing users are specifying LINK-BELT more and more . . . for dependability, for free-rolling action, for economy. Link-Belt Company — serving industry since 1875 — offers a COMPLETE LINE of mounted and unmounted Ball and Roller Bearings for every type of industrial application.

VARIETY OF MOUNTINGS for WIDE RANGE OF APPLICATIONS





LINK-BELT COMPANY

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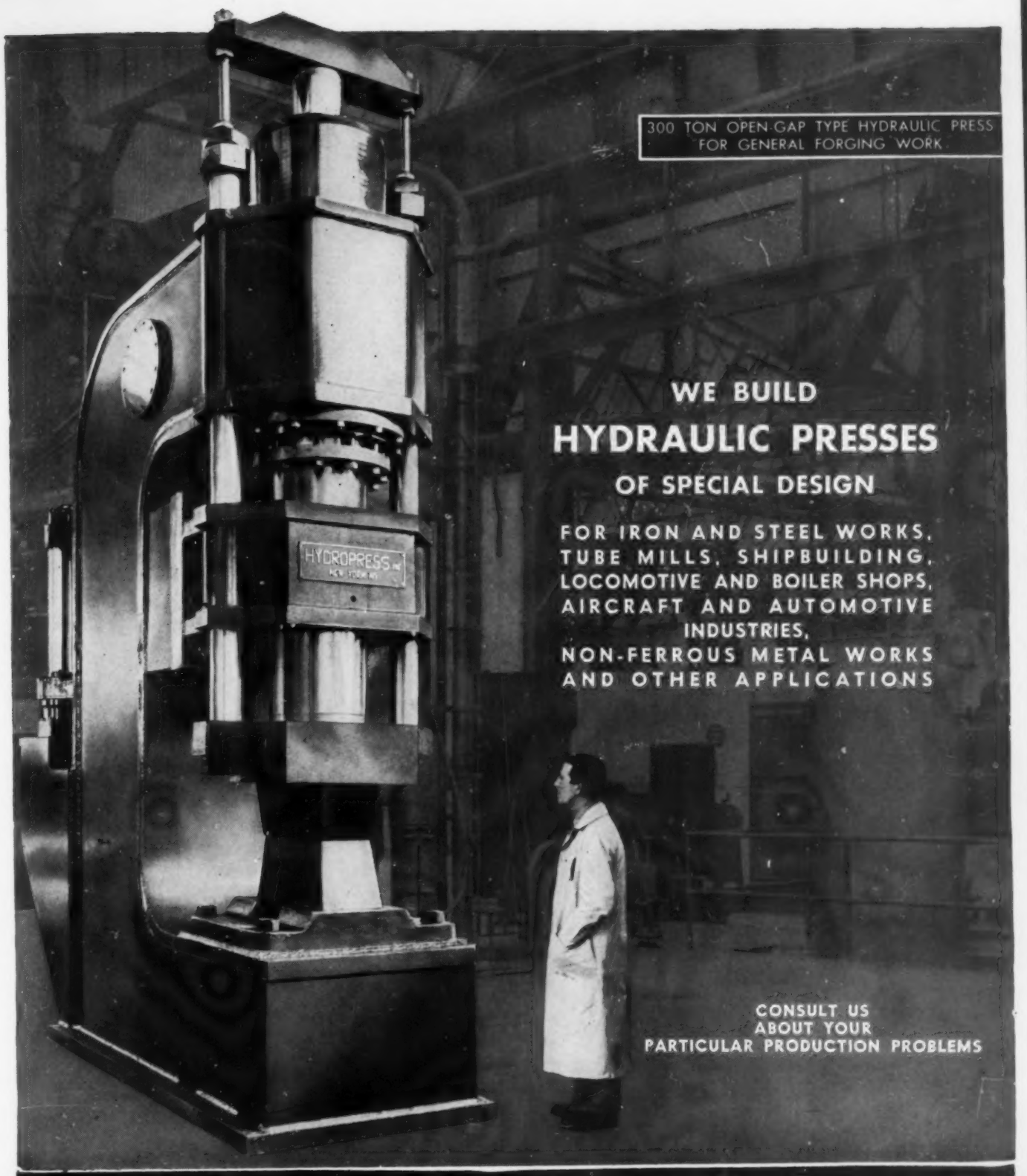

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EVERY STEEL PRODUCER MUST MAKE THIS *Choice:*

Shall I continue outmoded, manual conditioning of billets at excessive costs . . . or

Shall I invest in equipment that will cut my billet-conditioning costs?

Many leading steel producers have already made the "profit-wise decision" to install Bonnot Billeteers to take expensive, manskilling hand labor out of the billet-conditioning. And in each instance, Billeteer users describe their benefits like this:

- ★ ***Cut costs as much as 56% over hand conditioning methods. No wasted billet production, because flaws of any depth are quickly cut out.***
- ★ ***Less strain on manpower — less employee turnover in billet-sheds and greater overall efficiency.***
- ★ ***Fewer accidents; quoting one user, "only one disabling accident in 490,000 Billeteer-hours of operation."***
- ★ ***Steady production on schedule, shift after shift, YEAR AFTER YEAR.***

Get the whole story of how a Bonnot Billeteer can bring consistently, profitable efficiency to your billet-shed. Write today.

Engineered for Improved Production

The Bonnot Co.
STEEL EQUIPMENT DIVISION
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ALSO MANUFACTURERS OF SAWING • CRUSHING • PULVERIZING & MIXING EQUIPMENT
BILLET INSPECTION TABLES • DUST PUG MILLS • SINTER PLANT PUG MILLS

EC&M *TAB WELD GRIDS* designed for efficiency

Widths and Openings matched to ampere and radiation needs . .

Here's why these new *Tab-Weld* Resistors are unmatched in meeting the requirements of control service for crane and mill duty:

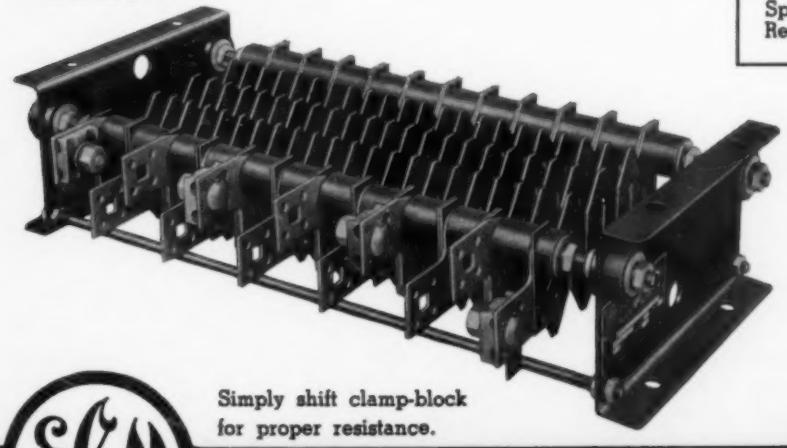
(1) Metal area and cooling surfaces are accurately proportioned for uniform temperature rise throughout each grid.

(2) Spot-welding of mated grid-ends and of taps to grid-ends eliminate burning at the grid eyes and at the taps.

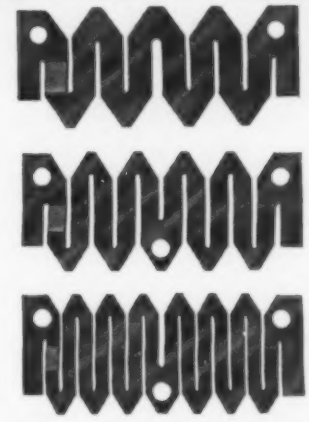
(3) Standard sections have the same size grid throughout the section.

(4) The large number of taps makes internal tap-shifting unnecessary.

For reduced maintenance where maintenance can be easily overlooked, switch to EC&M *Tab-Weld* PLATE RESISTORS.



Simply shift clamp-block for proper resistance.



3 x 3 = 9 grid sizes for wide horsepower range

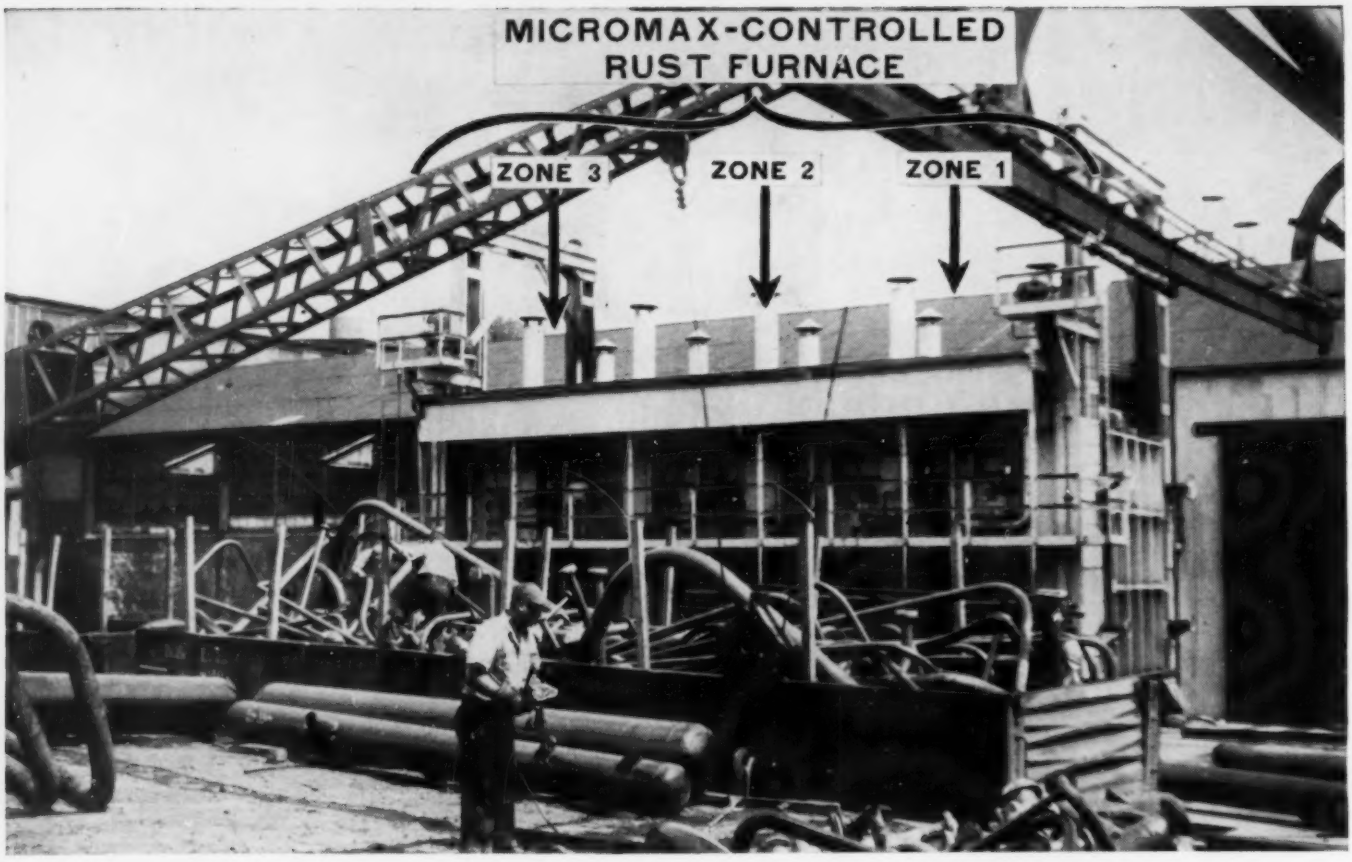
EC&M *Tab-Weld* GRIDS are stamped from corrosion-resistant steel in the above three designs. Three different gauges of steel per design give only nine grid sizes. Assembled in *"standard"* sections, these EC&M *Tab-Weld* Resistors are available in capacities up to 150 amperes without internal paralleling. For larger capacities, external paralleling of complete sections is simplified by the standard tap arrangement of each section.

Specify EC&M Bulletin 942 *Tab-Weld* Plate Resistors for Crane and Mill Auxiliary Control.

Specify EC&M Bulletin 942 Tab-Weld Plate Resistors for Crane and Mill Auxiliary Control

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79TH STREET • CLEVELAND 4, OHIO



Fabricated Piping is annealed by Benj. F. Shaw Co., Wilmington, Del., in the Micromax-controlled furnace. Close control prepares pipe for high-temperature, high-pressure service.

Contractor Meets Insurance Specs with Micromax Control

IN operating their new heat-treat department, the Shaw organization faces two typical piping-contractor's conditions. First, they require high-quality results to meet their own standards; second, their customers require air-tight proof of such results, for insurance and other reasons.

Micromax control, with record of each individual zone's temperature, helps metallurgist exercise close supervision of all temperatures throughout the anneal of Shaw piping.

To handle both situations, Shaw selected a heat-treating team of versatility and dependability. They got an outdoor-type, oil-fired, car-bottom furnace, and equipped it with Micromax Electric Control Pyrometers for fully-automatic temperature regulation.

The furnace accommodates both the big, intricately-formed welded piping, and the flanges and other fittings, which Shaw supplies to power plants and other industrial establishments. For uniform temperature distribution in so large a furnace, handling so wide a variety of loads, the fuel-oil firing system is divided into 3 zones, as shown in the photo above. Instrumentation of the Furnace provides each zone with its own Micromax Recording Controller. These 3 instruments not only regulate the fuel in proportion to demand, but also reset the equipment to maintain the correct temperature both when the furnace load changes, and when it is in effect changed by fluctuations in fuel, or in outside temperature, wind direction, etc. This instrumentation more than meets the first requirement — for high-quality results.

To meet the second requirement— proof of temperature-control results — Shaw has all three of the zone temperatures additionally recorded on one chart as one curve, by a Micromax 3-point instrument. This pyrometer's chart goes with the job to the purchaser of the piping, and demonstrates to the purchaser the quality of heat-treatment. As a Shaw man said, "It's absolutely essential that we use accurate, reliable controls. And we have them, in Micromax".

For further Micromax information, ask for Catalog ND44(1). Leeds & Northrup Company, 4942 Stenton Ave., Philadelphia 44, Pa.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES
LEEDS & NORTHRUP CO.

Irl Ad ND44-33A-626(1)

HAZEL-ATLAS
installs

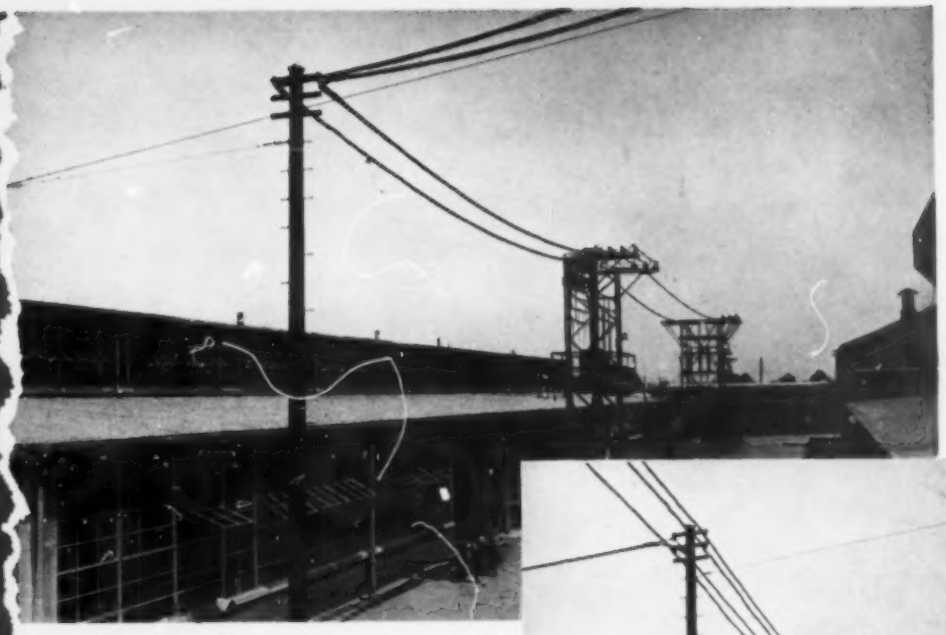
OKOLITE-OKOPRENE

SELF-SUPPORTING AERIAL CABLE

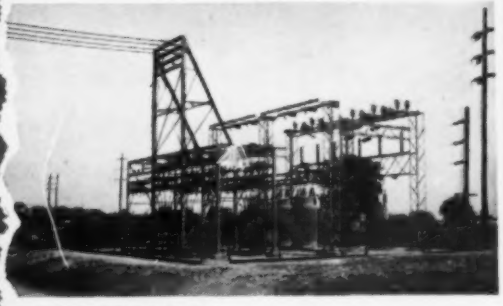
for
compactness
durability
dependability

ENGINEERS
PETER F. LOFTUS CORP.,
PITTSBURGH, PA.

ELECTRICAL CONTRACTOR
HARRY ALEXANDER, INC.,
WASHINGTON, D. C.



COMPACTNESS—self-evident space economy eliminates congestion, reduces clearance problems, gives a neater, more streamlined appearance in keeping with modern efficiency. Simple line tap, permitted with Okonite's Dualay* construction, serves the 2300/440 volt steel platform substation.



DEPENDABILITY—"stormsafe;" fewer service interruptions or outages; improved circuit regulation because of lower reactance; freedom from lead sheath troubles. 44kv/2.3kv jointly operated transformer and switching substation containing the Alabama Power Co. step-down transformer and the Hazel-Atlas Glass Co. outdoor oil circuit-breakers shown above.

ECONOMY—save on installation as well as maintenance costs with Okonite S/S cable. Reasonable first cost; simple, quick installation. Long spans require fewer poles; fewer items to be purchased and stocked. Exclusive Dualay assembly permits ample separation of conductors without cutting copper conductors or performing any operation on messenger. Practically no maintenance is required.

*U. S. Pat. 2430378

DURABILITY—no ring-cutting; permanently weatherproof, non-conducting Okoprene sheath; high-voltage, heat and moisture resisting Okolite insulation. These Okonite values mean long-lived, trouble-free circuits. Four circuits above are carried from station (background) on pedestal-mounted tubular steel poles with steel cross arms welded in place.

Four thousand feet of Okolite-Okoprene "Line-Tap" Self-Supporting Aerial Cable serve the new plant of the Hazel-Atlas Glass Company at Montgomery, Alabama. According to company officials, this installation provides a compact, durable and dependable arrangement, in keeping with the modern efficiency of the plant. It represents another proof of the advantages of Okonite Self-Supporting Cable for industrial applications.

Outdoors, on poles or on brackets attached to buildings – or indoors, where circuits can be carried overhead supported by beams or trusses – Okolite-Okoprene Self-Supporting Aerial Cables provide a modern, dependable and economical method of industrial power transmission. They are described in a 52-page manual available to electrical engineers and company executives. For your copy, send a request on your letterhead to The Okonite Company, Passaic, N. J.

THE BEST CABLE IS YOUR BEST POLICY

OKONITE insulated wires and cables

SINCE 1878

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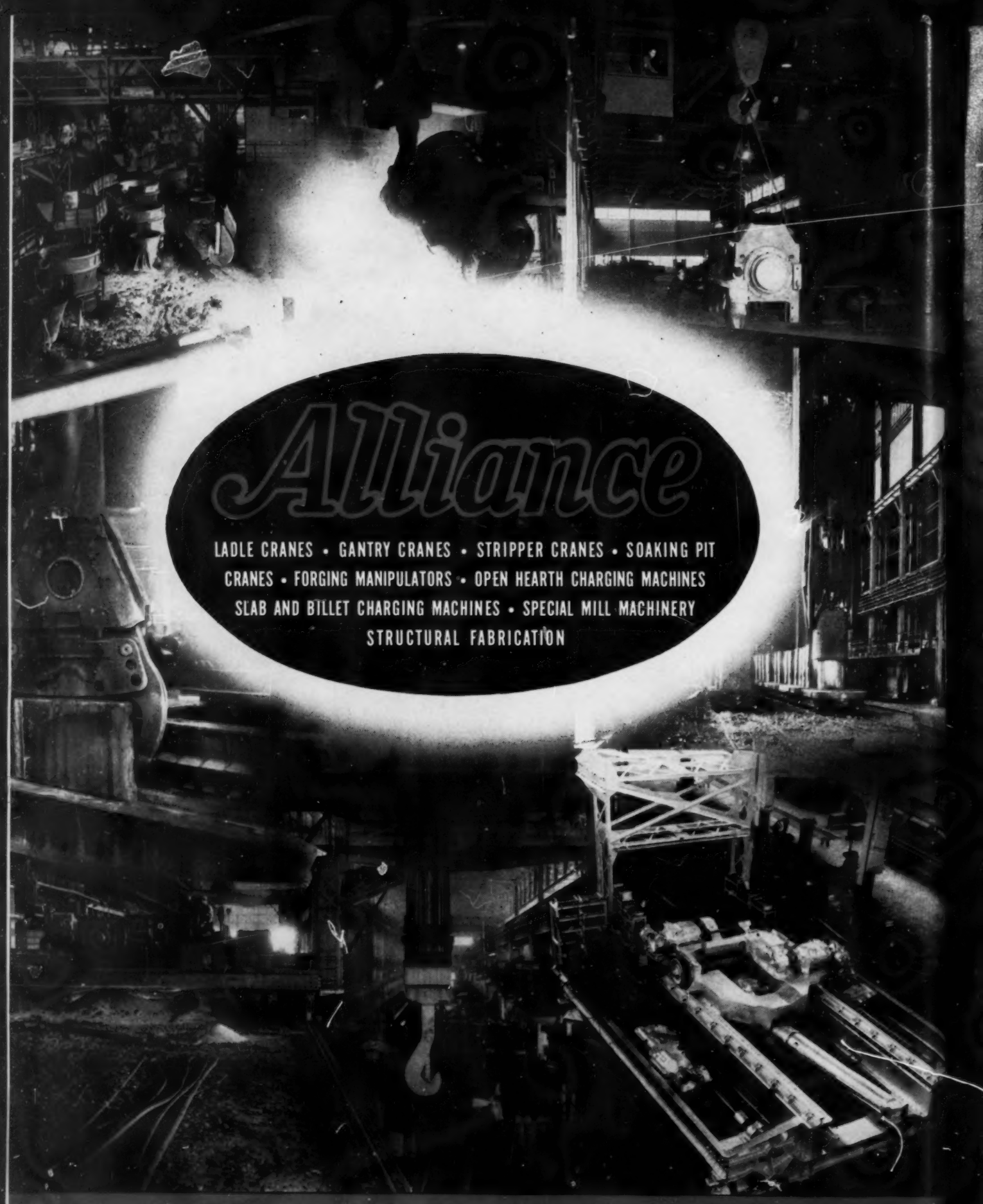
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LADLE CRANES • GANTRY CRANES • STRIPPER CRANES • SOAKING PIT CRANES • FORGING MANIPULATORS • OPEN HEARTH CHARGING MACHINES
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STRUCTURAL FABRICATION

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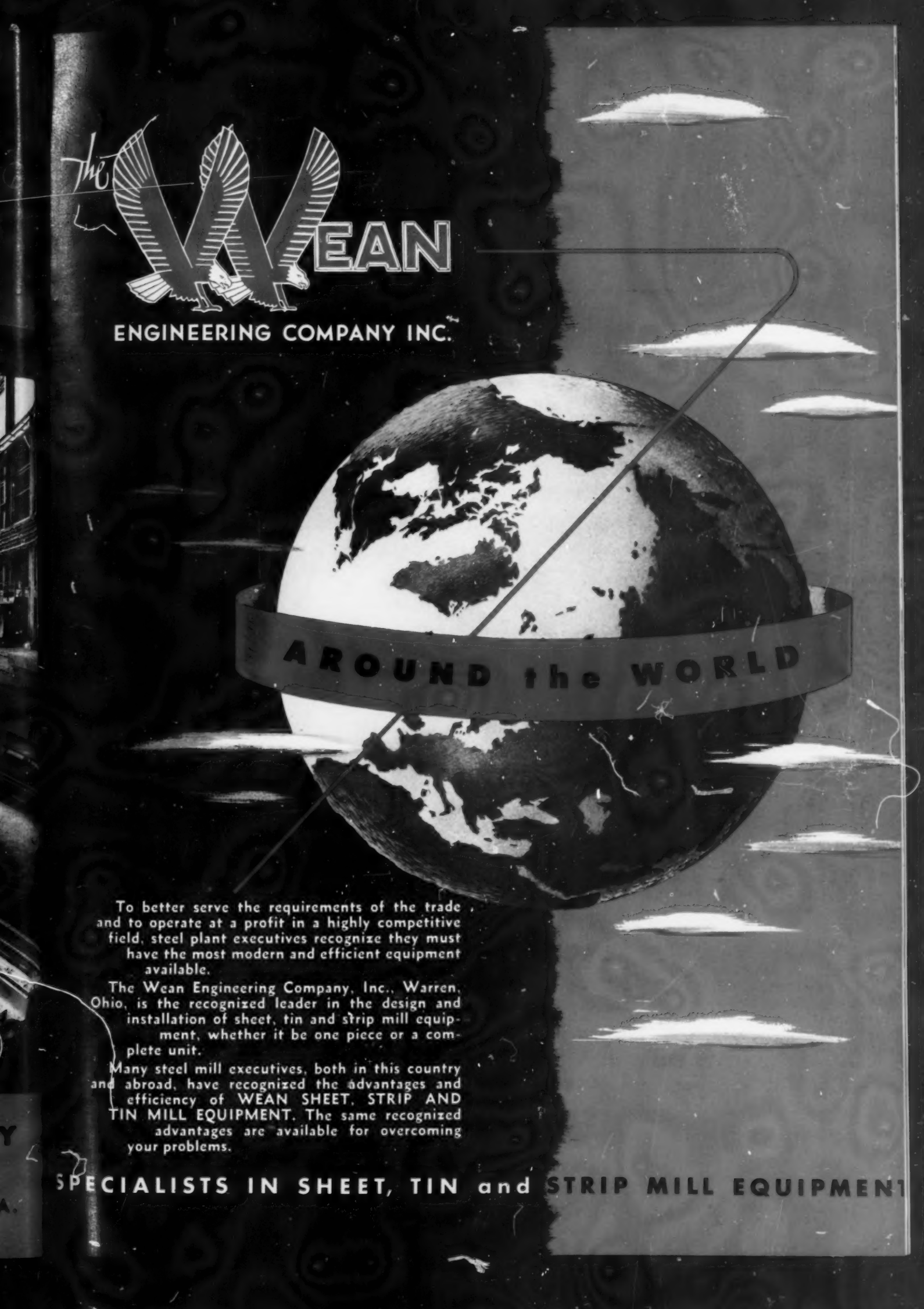
ALLIANCE, OHIO

Pittsburgh Office
1622 OLIVER BLDG., PITTSBURGH, PA.


the WEAN
ENGINEERING COMPANY INC.
AROUND the WORLD
To better serve the requirements of the trade, and to operate at a profit in a highly competitive field, steel plant executives recognize they must have the most modern and efficient equipment available.
The Wean Engineering Company, Inc., Warren, Ohio, is the recognized leader in the design and installation of sheet, tin and strip mill equipment, whether it be one piece or a complete unit.
Many steel mill executives, both in this country and abroad, have recognized the advantages and efficiency of WEAN SHEET, STRIP AND TIN MILL EQUIPMENT. The same recognized advantages are available for overcoming your problems.
SPECIALISTS IN SHEET, TIN and STRIP MILL EQUIPMENT

Wean EQUIPMENT Corporation

A COMPLETE ENGINEERING SERVICE FOR WIRE MILL INSTALLATIONS

Complete Installations for Electro Galvanizing, Hot Dip Galvanizing, Patenting, Tinning, Wire Flattening, Nail Galvanizing and Blueing.

Complete Equipment for the Manufacture of Hexagon Netting, Hinge Joint Fence and Barbed Wire.

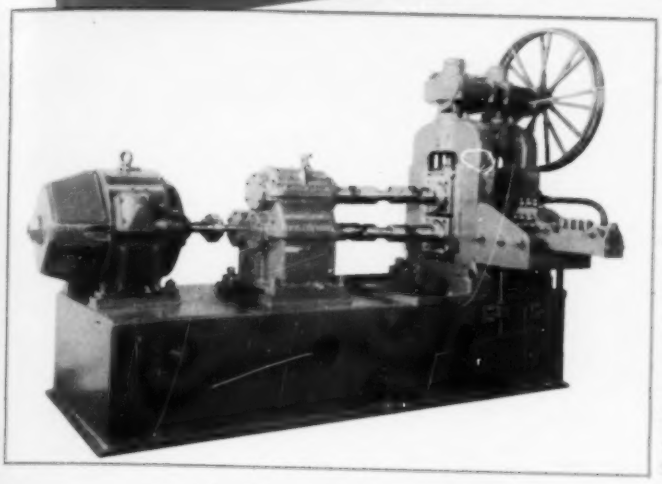
CHECK WEAN FIRST FOR WIRE MILL EQUIPMENT

NARROW STRIP MACHINERY
(For 36" widths or narrower)

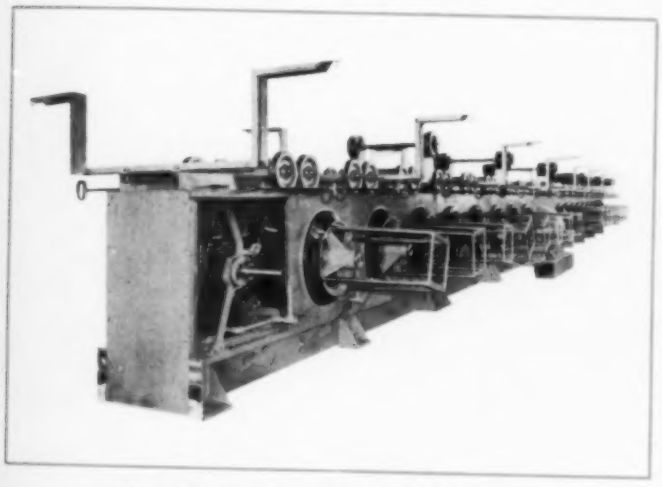
Slitting Installations. Cut to Length Installations. Bearing Metal Coating Installations. Two-Hi Rolling Mill Applications. Strip Grinding Installations. Levelers, Uncoilers, Pinch Rolls, Shears for Narrow Strip Processing Lines.

WEAN EQUIPMENT CO

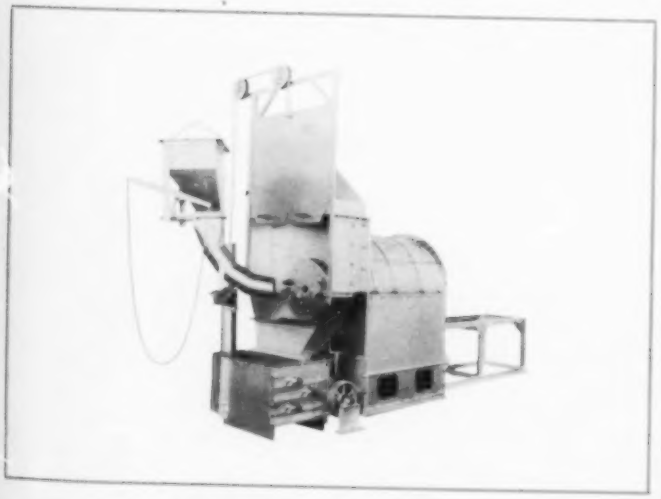
Process



2—Hi Wire Flattening Mill



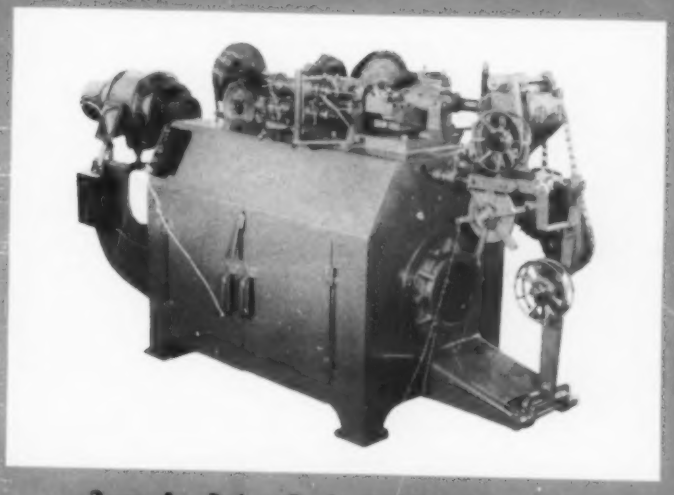
Wire Galvanizing Take-Up Frame



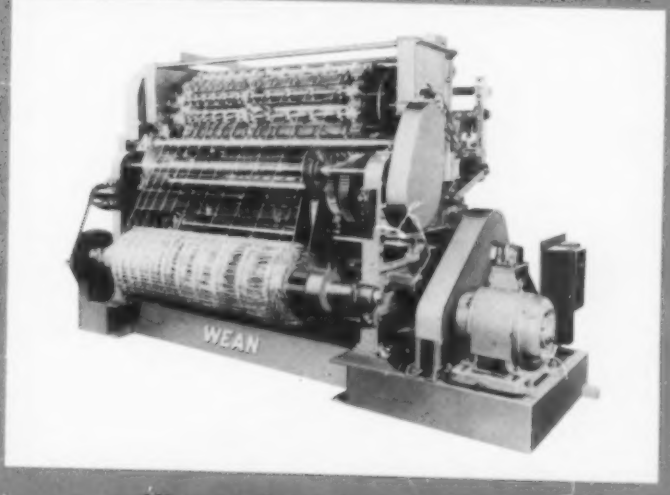
Nail Galvanizing Unit

Product

Hexagon Netting Machine



2 or 4—Point Barbed Wire Machine



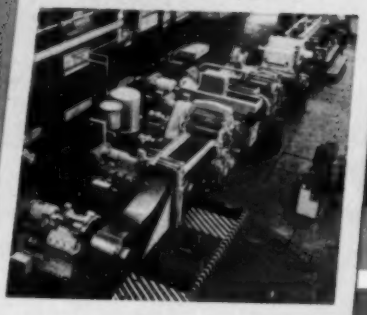
Hinge — Joint Fence Machine

The WEAN ENGINEERING Company, Inc.

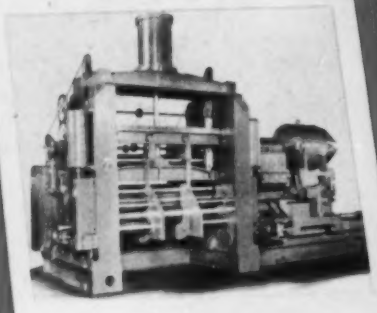
WARREN, OHIO

Continuous Strip Pickle Line

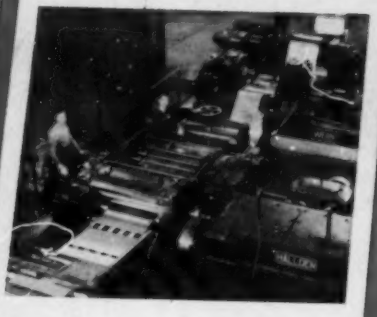
Continuous Coating Line



Processing Uncoiler

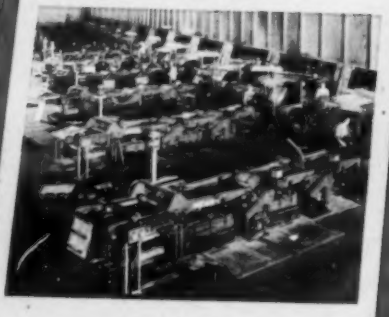


Tin Plate Shearing Line



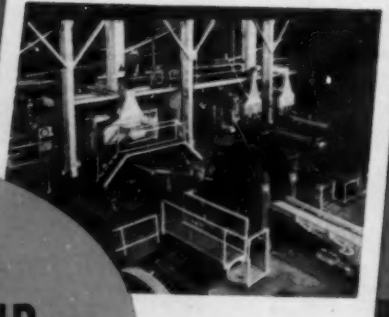
Continuous Electrolytic Cleaning Line

Hot-Dip Tinning Units



Continuous Hot-Dip Galvanizing Line

Mechanized Sheet Mill



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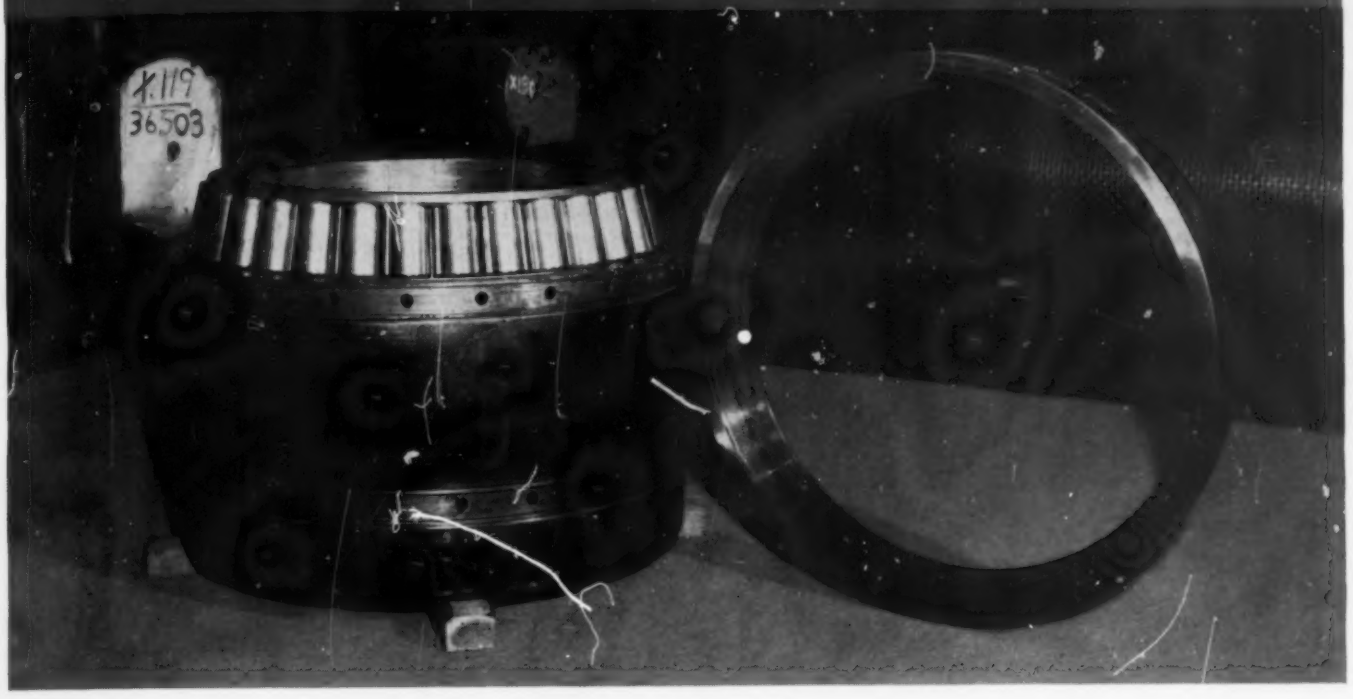
Litho U.S.A.

THIS TIMKEN® ROLL NECK BEARING ROLLED 6,297,083 TONS OF STEEL IN 12 YEARS' SERVICE. STILL GOOD FOR MORE



It's the No. 5 back-up roll bearing in the 100" semi-continuous sheared plate mill at the Homestead works of Carnegie-Illinois Steel Corporation.

This mill went into operation on December 1, 1936 with Timken bearings on back-up and work rolls; the No. 5 bearing was removed for inspection August 14th, 1949 and found to be in very good condition after its long, tough 6,297,083-ton tour of service.

The mill proper and auxiliary equipment were built by United Engineering and Foundry Co., Pittsburgh, Pa.

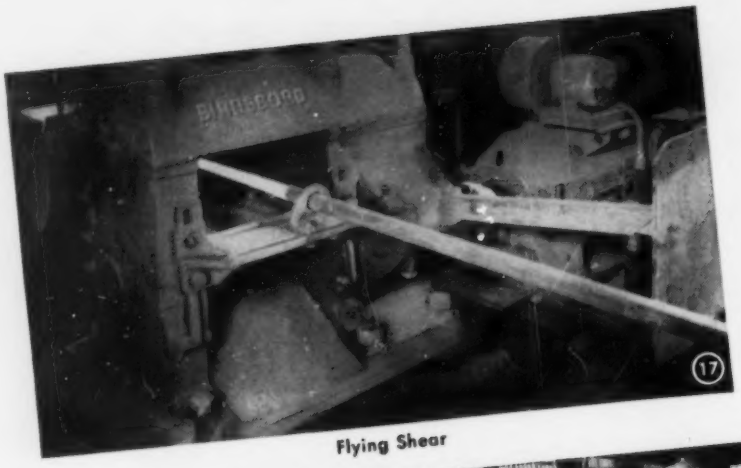
THE TIMKEN ROLLER BEARING COMPANY, CANTON 6, OHIO

Cable Address "TIMROSCO"

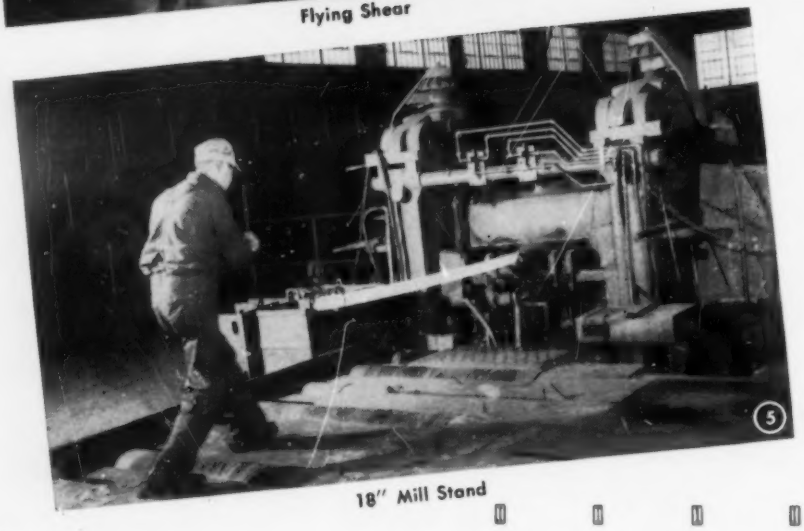
TIMKEN

ROLL NECK BEARINGS

NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION



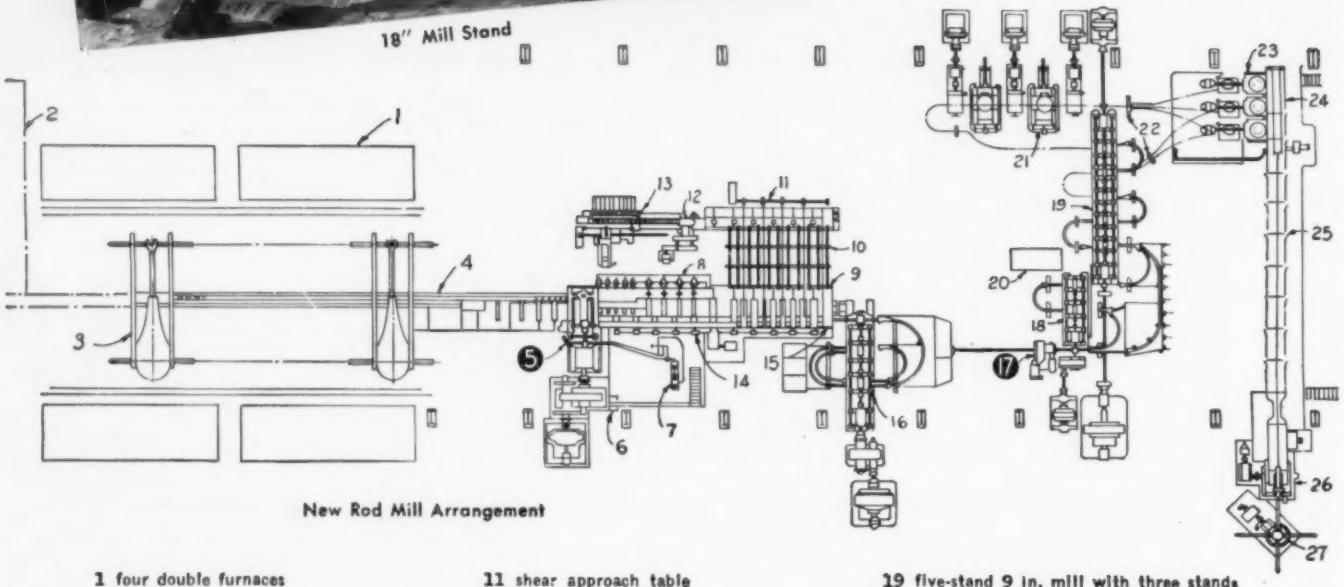
Flying Shear



18" Mill Stand

....From building a single machine...

to complete steel mill installations, you can count on the versatility of Birdsboro's design-engineering staff for the economical solution of any of your special problems.



New Rod Mill Arrangement

1 four double furnaces
2 mill approach table
3 two charging machines
4 18 in. mill approach table
5 18 in. mill stand
6 18 in. mill control pulpit
7 tilting table and crop shear hydraulic drive
8 18 in. mill tilting table
9 mill runout table
10 transfer
11 shear approach table
12 shear
13 shear gage table, gage, kick-off and cradles
14 12 in. mill approach table
15 oval turning device
16 3-stand 12 in. mill with repeaters on both sides
17 flying shear
18 two-stand 9 in. mill and repeaters on both sides
19 five-stand 9 in. mill with three stands on one drive, and two stands on another, and repeaters
20 mill control pulpit
21 five-stand continuous mill
22 switches
23 three coilers
24 feeder coil conveyor
25 main coil conveyor
26 unloader
27 revolving bundle holder

BIRDSBORO STEEL FOUNDRY & MACHINE CO. • BIRDSBORO, PA.

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REDUCE MAINTENANCE COSTS BY USING

HOMOGENEOUS LEAD LINED
TANK CARS
FOR TRANSPORTATION OF
CORROSIVE LIQUIDS
OVER
I.C.C. CONTROLLED TRACKAGE
3,600 TO 10,000 GAL. CAP.

HOMO-
GENEOUS
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Lined
TANKS
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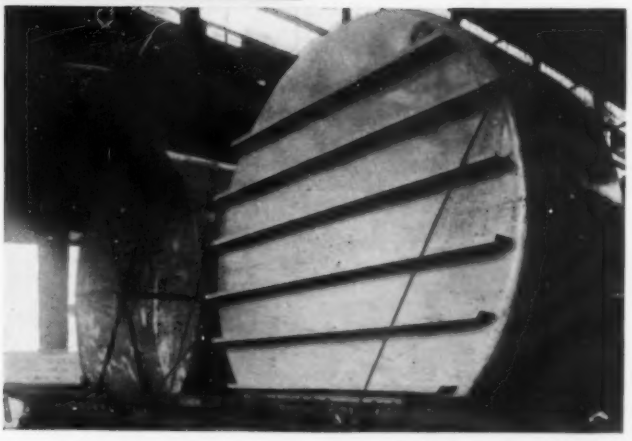

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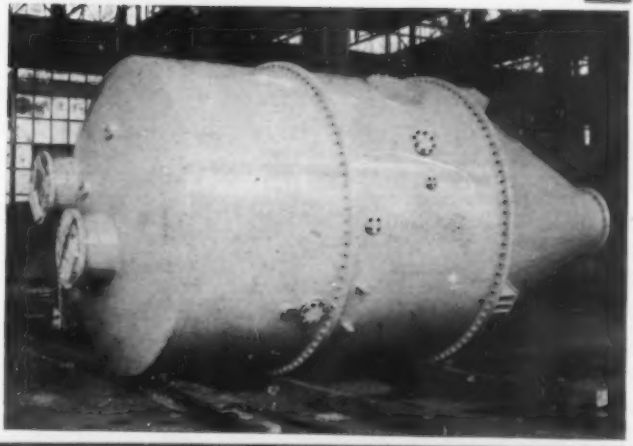
HOMOGENEOUS LEAD LINED
PROCESSING EQUIPMENT
FOR
PYRIDINE MANUFACTURE
AND
OTHER COKE PLANT
BY-PRODUCTS



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SALES OFFICES

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140 CEDAR STREET
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1217 FARMERS BANK BLDG.
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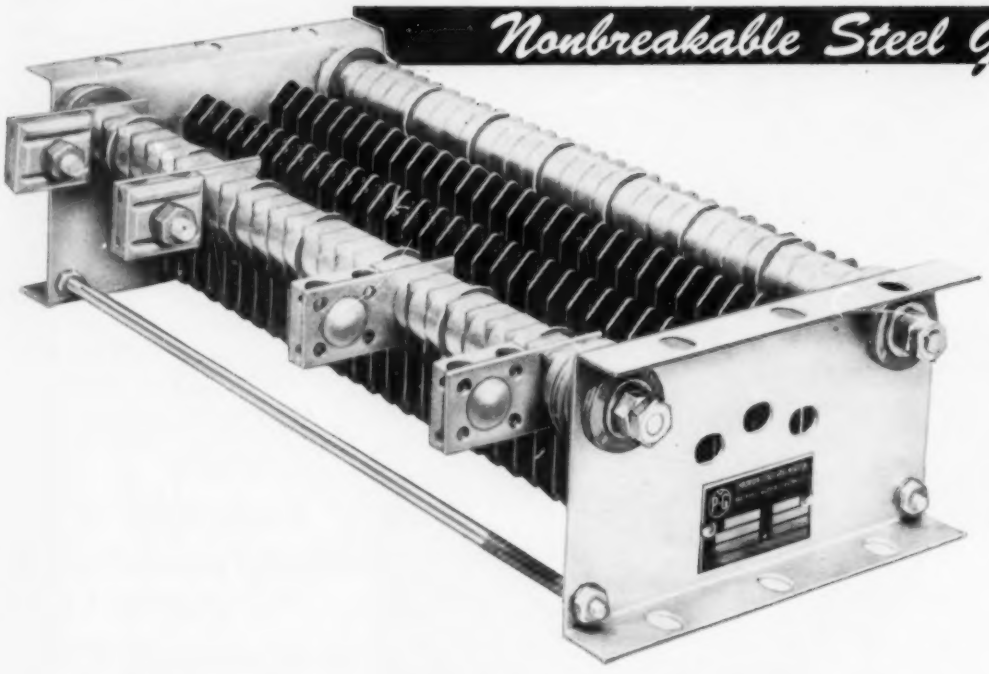
when PERFORMANCE

IS IMPORTANT TRY . . . POST-GLOVER

Nonbreakable Steel Grid Resistor



- All Steel Construction
- Mica Insulation
- Corrosion Resistant
- Unaffected by Vibration or Moisture
- Provision for Expansion
- Adequate Ventilation
- Rugged Terminals

Rugged

Built of Steel and Mica—nothing to break. Light in weight yet dependable. Remarkably constant resistance values regardless of temperature or age.

Original Grid Design

Provides a shape assuring maximum ventilation. Heat is evenly distributed. With all parts of grid equally exposed, heat is rapidly dissipated.

For any job

Where constant "trouble free" resistor service is wanted . . . you can safely specify P-G Steel Grid Resistors and get better performance with lower maintenance.

Complete data given in **BULLETIN No. 500 . . .** Copy on request.

P-G

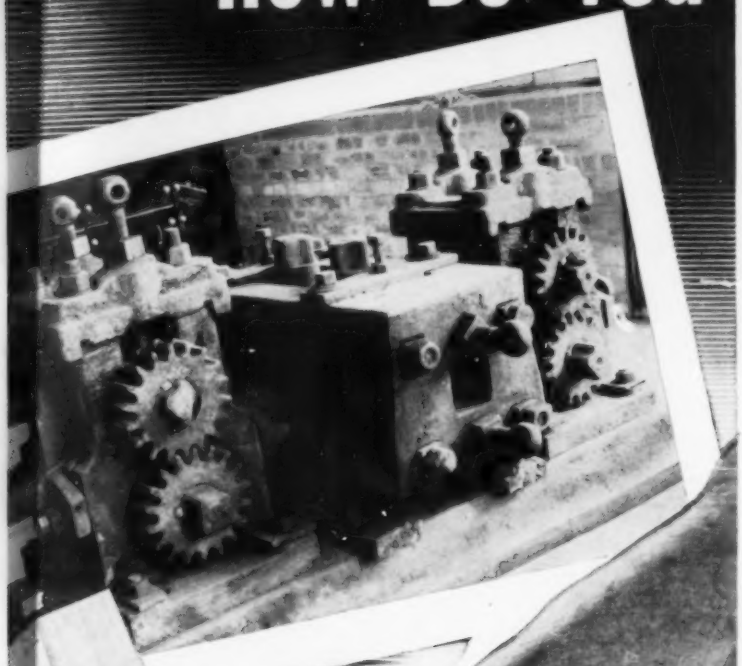
The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

How Do You Measure Progress?



Progress in rolling mill design is measured in dollar and cents. When a new mill will outdo its pred ecessor in output, accuracy and conversion cost per ton—that's progress.

The many Morgan mills in operation and unde construction are proof that progress in this field i measured with a Morgan yardstick. How abou getting our ideas on your new project?

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

Rolling Mills - Morgoil Bearings - Wire Mill
Regenerative Furnace Control - Air Ejector

English Representative: International Construction Company
56 Kingsway, London, W.C. 2, England

RM-24

Above is shown a horizontal-vertical rolling mill built in 1867. Here is its modern counterpart built by Morgan in 1947.

new drive for 66" continuous pickling line permits faster acceleration, cuts maintenance costs!

General Electric-engineered drive simplifies operation, reduces downtime, helps increase strip steel output!

Of outstanding interest to steel mill operators is a new 66-inch high-speed continuous pickling line now in operation in a large Eastern mill. Electrically engineered, co-ordinated, and equipped by General Electric, it provides important features such as these to increase output and cut costs:

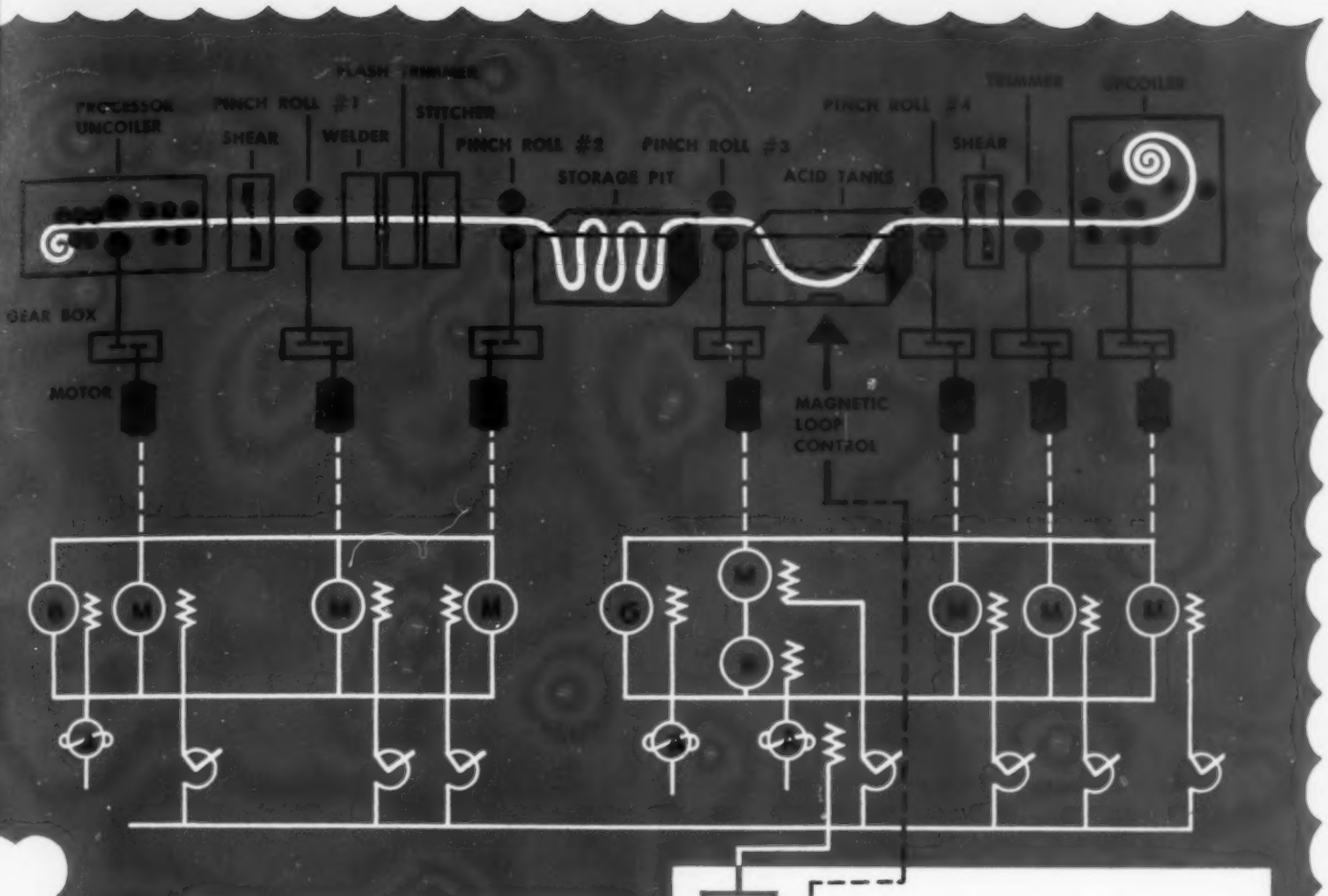
Acceleration rates up! Amplidyne control of separate adjustable-voltage generators for the entry and delivery ends makes possible much faster acceleration and deceleration, limited only by the commutating ability of the motors and generators.

Maintenance costs down! A new magnetic loop control utilizing for the first time the Amplistat—General Electric's new static magnetic amplifier—regulates the loop position in the pickling tank. By regulating the loop position without the use of dancer rolls or dancer roll rheostats, the problem of corrosion of these rolls and rheostats—and resulting costly downtime—is eliminated.

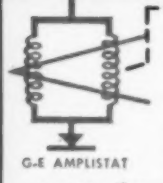
Output increased! Faster acceleration and deceleration of the drive makes it easier for operators at the entry end to keep up with the delivery end, simplifies operation, and helps maintain a higher rate of output.

Here is further proof that—whatever *your* drive problem—experienced G-E engineering can help turn it into a successful installation. A G-E steel mill specialist will be glad to discuss it with your technical staff. Phone him at your nearest G-E office. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC



HERE'S HOW IT'S ENGINEERED!



The drive motors (M) for the various machines which make up this continuous pickling line are divided into an entry section and a delivery section. Each section is supplied by an individual generator, making it possible to operate them independently. Each generator (G) is excited by an amplidyne exciter (A), which regulates voltage and provides current limit for rapid acceleration and deceleration. Speed adjustment of individual machines in each section is accomplished by motor field control. A magnetic loop control regulator automatically maintains the position of the strip catenary in the acid tanks. The signal produced by the pick-up unit is amplified first by an Amplistat and then by an amplidyne exciter. The amplidyne excites a booster generator (B) in series with No. 3 pinch roll motor, and thus controls the speed of No. 3 pinch roll to correctly position the strip.

Shown here are the flash welder and entry-end control desk. The tail end of each coil is welded to the front end of succeeding coils in order to provide an endless strip through the pickling tanks. Delivery strip speed is 500 FPM, making this G-E equipped line one of the industry's fastest.

another example of GENERAL ELECTRIC drive engineering at work!

Grefco Sillimanite Pads and Mortar for TROUBLE-FREE BLAST

TESTED 10 YEARS
PROVED IN 20 HEARTHS
NO OTHER HEARTH CONSTRUCTION HAS SUCH A RECORD FOR TROUBLE-FREE OPERATION

GREFCO pioneered the use of monolithic, Sillimanite Hearth Pads for Blast Furnaces in 1938 as the remedy for serious blast furnace troubles that were reducing production, causing expensive rebuilding of furnaces and creating working hazards. Since the first hearth pads were installed in a furnace in Chicago in 1938, Grefco Sillimanite Pads have been built into the hearths of more than twenty furnaces. *All of these hearths have had good runs and many are still in operation. Not one has had a breakout or any other hearth trouble. The first furnace produced approximately 2,500,000 tons before its hearth was rebuilt. Others have already passed this mark.*

The use of Sillimanite Hearth Pads gets at the trouble at its source. The pads cover and protect the bottom blocks, thereby retarding metal seepage into joints and formation of salamanders.

Grefco Sillimanite Pads are made with Grefco Sillimanite Ramming Mix. The Sillimanite is mixed with water and rammed into place with air hammers. Since the pads are installed to resist erosion and salamander formation, they can be used in any of the three constructions shown, depending on service conditions.

GREFCO SILLIMANITE MORTAR

For really superior service from your blast furnace hearth and bosh, use Grefco Sillimanite High Temperature Bonding Mortar for laying all brick. Grefco Sillimanite Mortar assures minimum metal seepage into joints because of its high refractoriness and low shrinkage. Its perfect workability insures ease of installation and safe, thin joints.

Both the Mortar and the Ramming Mix are shipped dry in 100 lb. bags.

INSIST ON GREFCO SILLIMANITE PRODUCTS

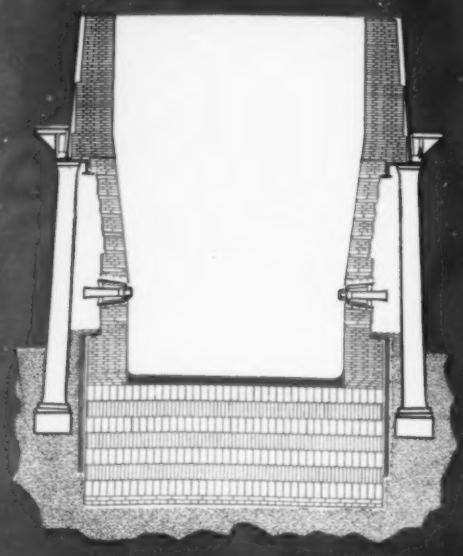
Grefco Sillimanite Ramming Mix is made from natural Indian kyanite, calcined and gap-grained sized by Grefco's special process to insure maximum density.

Grefco Sillimanite High Temperature Bonding Mortar, also made from kyanite, has no superior as a highly workable, low-shrinkage mortar.

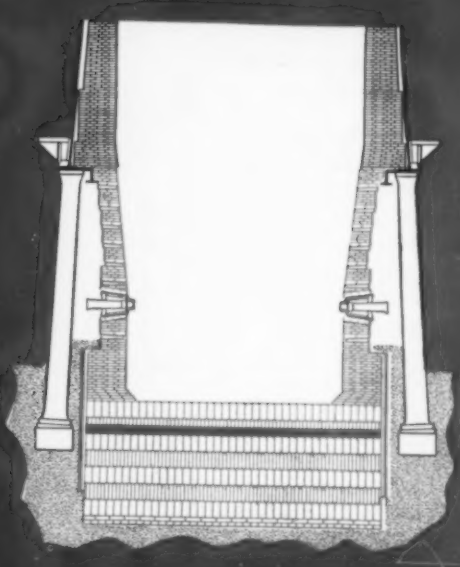
USE GREFCO SILLIMANITE PADS AND MORTAR IN YOUR NEXT BLAST FURNACE HEARTH

Use Grefco Sillimanite High Temperature Bonding Mortar for laying all brick below the mantle. Its exceptionally low shrinkage, high refractoriness and resistance to slag action make it an ideal joint refractory

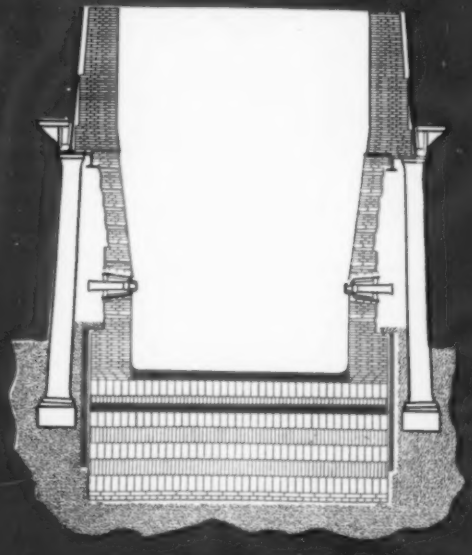
FURNACE HEARTHS



GREFCO SILLIMANITE PADS were first installed on hearth surfaces. Such pads should be of least 9 in. thick. Grefco Sillimanite Ramming Mix forms a perfect monolithic pad that covers and protects the bottom during the blowing-in period.



GREFCO recommends pads at least 9 in. thick installed 27 in. below hearth surface for best results. In this position Grefco Sillimanite Ramming Mix becomes a highly refractory monolithic layer which retards salamander formation.



Best results are obtained from a pad at surface to protect during blowing-in, and another in the subhearth to retard salamanders.

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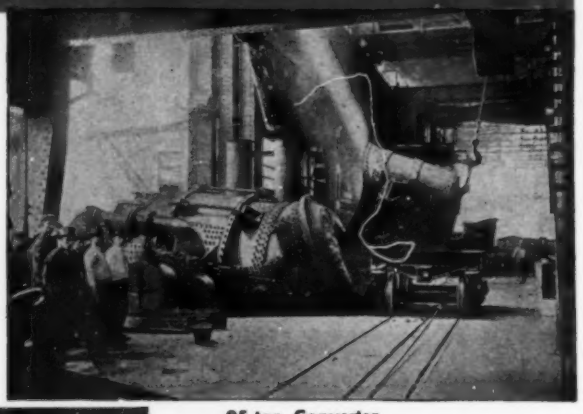
DUPLEX STEEL PLANTS

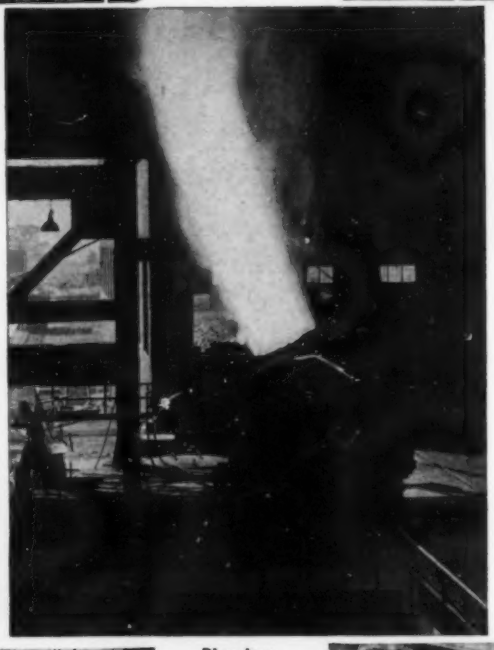
600-ton Mixer



25-ton Converter

These pictures give but small evidence of Pennsylvania Engineering Corporation's contribution to the Steel Industry.

Backed by many years of experience and the great number of installations in the many Steel Plants, the Pennsylvania Engineering Corp. is prepared to design, fabricate and erect complete Duplex Plants, including Mixers — 25 tons to 2000 tons capacity, Open Hearth Furnaces —50 tons to 400 tons capacity— both tilting and stationary, Converters — 5 to 50 tons capacity, converter Jack Cars, Bottom Oven Cars, Regulating Valves, Slag Cars, Ladles, Ladle Cars, Transfer Cars, Jib Cranes and Hauling Systems.



Blowing Charge in 15-ton Converter

Installations of some of the illustrated equipment at

Inland Steel Company
Tennessee Coal, Iron & Railroad Company
Youngstown Sheet & Tube Company
National Tube Company
Carnegie-Illinois Steel Corporation
Republic Steel Corporation
Bethlehem Steel Company
Great Lakes Steel Corporation
Weirton Steel Company
Jones & Laughlin Steel Corporation
Ford Motor Company, River Rouge
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Algoma Steel Company, Canada
Steel Company of Canada, Ltd.
Compania Siderurgica del Mediterraneo, Spain
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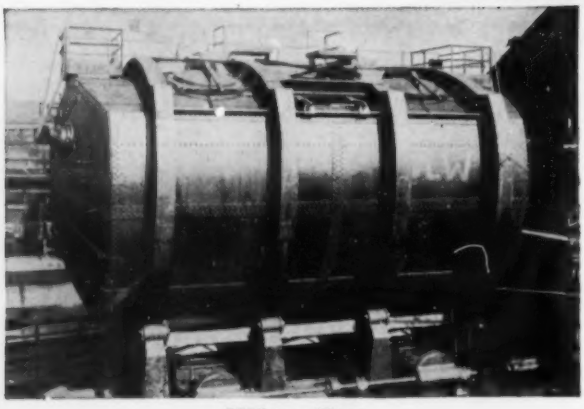


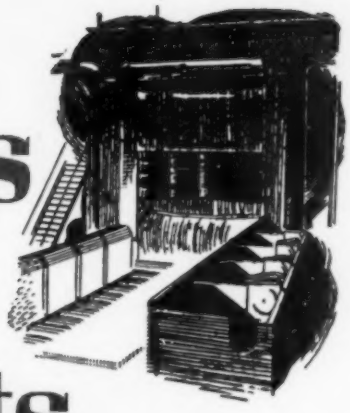
1500-ton Mixer

400-ton Tilting Open Hearth Furnace

Pennsylvania Engineering Corp.

New Castle, Penna.

Crops *and* Shorts



WITH the beginning of every year come numerous requests for advance information on what the year will bring, industry-wise. Having broken our crystal ball shortly after the 1948 election, we can now depend only on reports and opinions of our friends in industry. For 1950 these indicate that production in the steel and non-ferrous metal industries may be 5 - 7 per cent above 1949, but 7 - 12 per cent under 1948. Activity in machinery may be slightly higher than in 1949, but well under 1948. In general, capital expenditures have been dropping, and their trend is uncertain. Automotive production will probably be less, but the oracles predict that personal income and dividend payments will be higher.

The steel industry expects full production to extend into the second quarter of 1950, with a drop-off about mid-year. One producer expects the production rate to fall to 70 per cent or less of capacity, but this same producer has already appropriated more money for capital expenditures in 1950 than the company spent in either 1948 or 1949.

All in all, it doesn't look too bad, although competition will be keener and business is going to be something to go after, rather than something that flows in.

▲

GEORGE N. CRAIG, national commander of the American Legion, says: "Every American is entitled to life, liberty and an automobile in which to pursue happiness." And we thought the important thing was the fair sex — as long as we have life we pursue them, and as long as we have liberty we have happiness.

▲

CLOSE on the heels of the price changes announced by steel producers came the screams of Senator J. C. O'Mahoney, of Wyoming, and Representative Emanuel Celler, of New Jersey. The latter called the increases an act of "social irresponsibility" and said that this "heedless action boldly points the need for a re-examination of the prerogatives of bigness."

The price increase, which averaged $3.50 - $4.00 per ton for various producers (or about 4 per cent), is made up of higher base prices and higher extra charges, in approximately equal proportions. Electric sheets had the greatest raise — about 15 per cent, while hot and cold rolled sheet and strip were upped considerably. Some items received little change, while stainless prices remained the same. Tinplate prices were reduced. In general, the changes were pointed toward making every item show some profit.

INCENSED by the vicious attacks of O'Mahoney and Celler, E. T. Weir, chairman of National Steel Corp., called for a "fair deal for the steel industry," which he feels is pilloried more than any other. He stated that the price increases, which will add about $250,000,000 to the income of the entire steel industry, were necessary because of rising costs, including the new pension plans, higher transportation costs, and higher prices for some raw materials.

Mr. Weir said that present tax laws permit his company to deduct less than 40 per cent of the amount that must actually be spent to replace wornout equipment. He expects 1949 profits to be less than the 1948 figure, and 1950 to be under 1949. He asked why, if profiteering accusations are correct, steel stocks are selling for less than their book value and still remaining so undesirable to investors.

▲

IT'S a good thing to lay out a schedule for your future work, but it's more important to do the work. Sometimes we get so busy doing urgent things that we have no time for important things.

▲

TWO months ago, this department carried some observations regarding the relations between steel managements and their salaried personnel. Those remarks evidently struck a responsive chord. One correspondent wrote, in part: "I found that the only time I ever got a raise was when the men in the mill received a wage increase. In other instances, other employees got wage increases when they threatened to quit.

"My impression of working in the engineering field for . . . . . is that it is a hell of a good place to get experience, but once you get this experience, get out if you want to make a decent salary. In my case, the only regret I had about leaving . . . . . is that I didn't leave sooner."

Here is a condition that should be looked into, as it may be at the root of the often-mentioned shortage of young but experienced engineers in the industry.

▲

THAT perennial jack-in-the-box, expansion of the steel industry along the Atlantic coast, bobbed up again, first, as a result of New England efforts, and more recently with the acquisition by Carnegie-Illinois Steel Corp. of 3800 acres on the Delaware River about 30 miles north-east of Philadelphia. The New England proposal has been investigated and turned down by at least five major producers, but its sponsors have not given up. The purchase of land by Carnegie-Illinois is more concrete, and finally pins down a site that has for years ranged up and down the coast from New Hampshire to Virginia. Construction of the plant, however, is not an item of the near future, but it is certainly a probable development as foreign ores become more important in steel economy.

▲

A DOCTOR is reported to have discovered that radio is sometimes beneficial in cases of deafness. Deafness is also sometimes beneficial in cases of radio.

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because of
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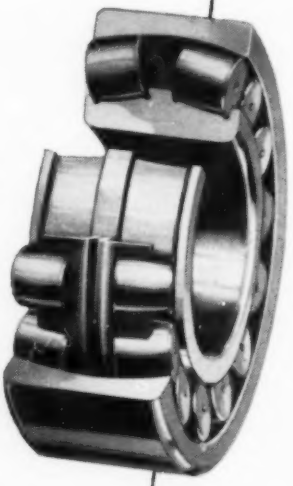

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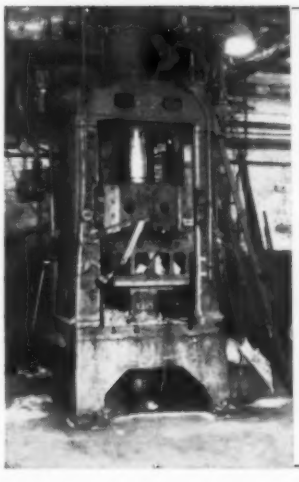

Time Saved, Cost Cut

in installing the bed for this 30-ton hydraulic press. Bed is 8′ by 8′ by 1½′ thick. The press was moved, foundation dug out of dirt floor, new foundation poured with Lumnite and ordinary concrete aggregate bed, and the press put back in place in less than 24 hours! Time off the job was kept to bare minimum. And maintenance costs are next to nothing for durable Lumnite concrete.

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Heat-resistant floor and hydraulic press bed at Minneapolis-Moline Co., Hopkins Plant, Minneapolis, Minn.

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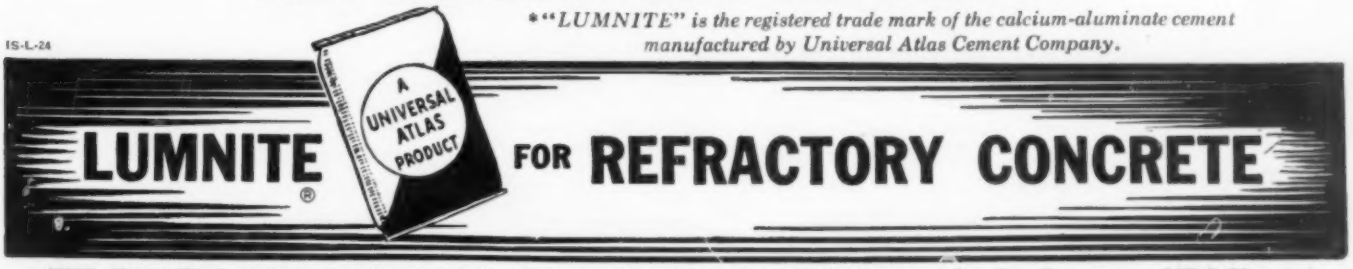

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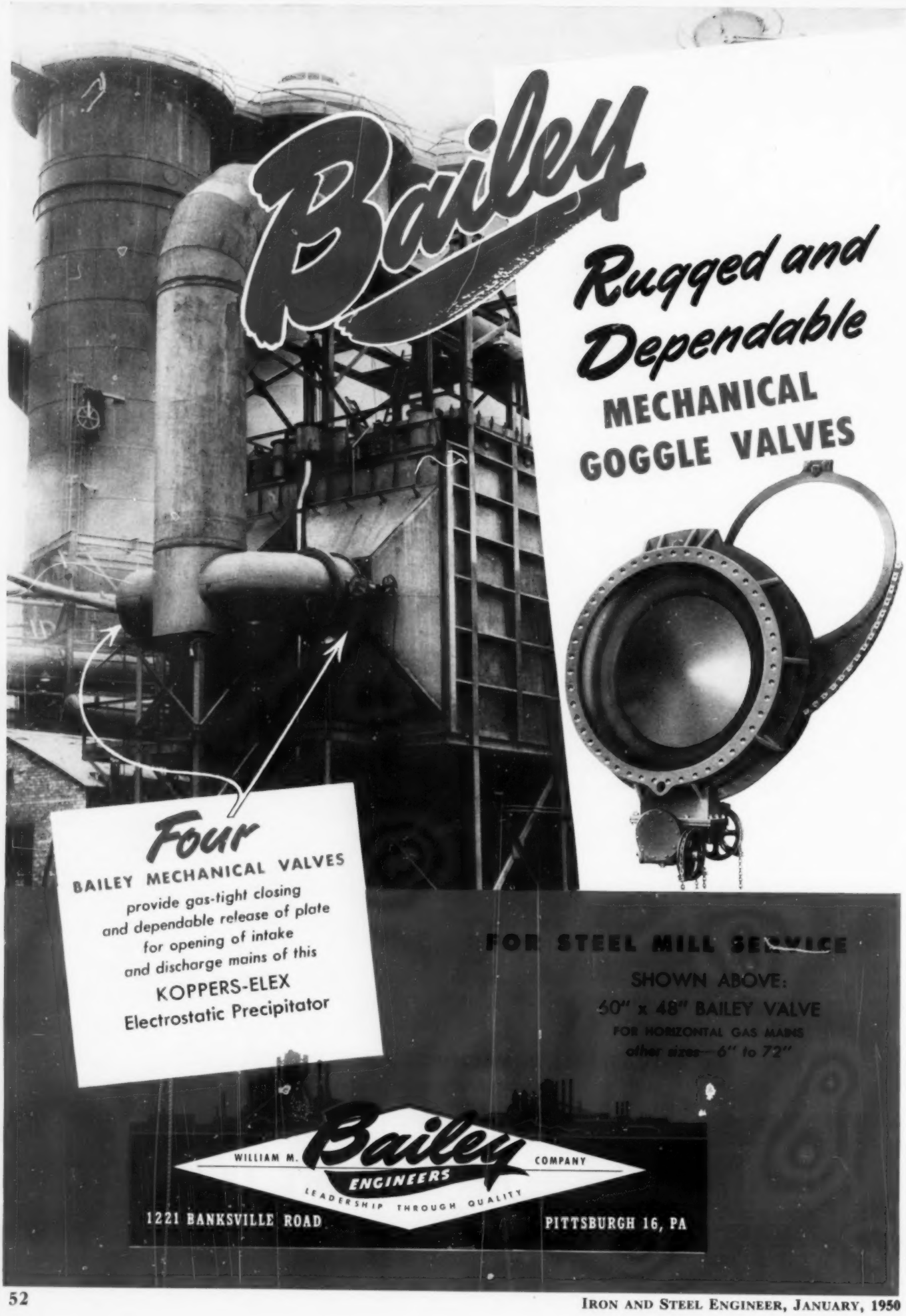
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Iron and Steel ENGINEER

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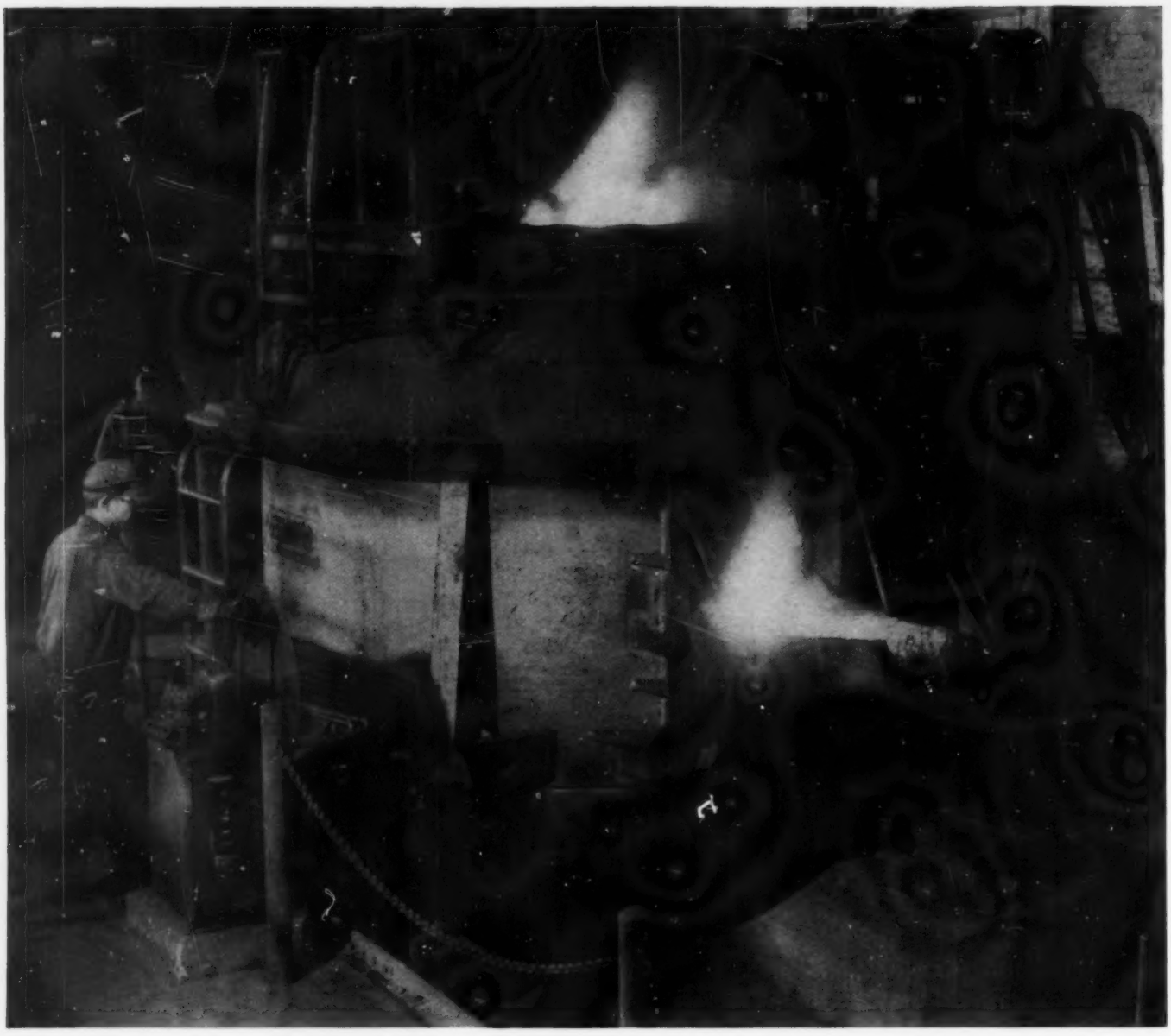

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FIVE YEARS OF BLAST FURNACE OPERATION UNDER ELEVATED TOP PRESSURE

. . . . further operational experience with pressure blowing blast furnaces bears out earlier claims for higher production, greater coke economy and less flue dust . . . .

By FRANK JANECEK
Blast Furnace Engineer
Republic Steel Corp.
Cleveland, Ohio

▲ WHILE necessity is the mother of invention, it was war that made it necessary to increase iron production from existing equipment. This in 1942, was the problem facing the Office of Production Research and Development Division of the National Academy of Sciences.

One of the processes offering considerable hope, was the known fact that, reduction of iron ore is accelerated when carried on under elevated pressures. This research group, through the Defense Plant Corp., which had under construction a number of blast furnace plants throughout the country, decided to incorporate the equipment necessary to verify on a commercial scale, the laboratory results. Thus, in one step, elevated pressure operation left the laboratory and was appended to a blast furnace, not a small, or medium size unit, but to one of the largest then nearing completion. The unit chosen was the 27 ft 0 in. diameter furnace at Cleveland being built by Republic Steel Corp. for the Defense Plant Corp.

To help bridge the gap from the laboratory, a group of some of the best operating men in the country met to consider the practical aspects. This group had as chairman, T. L. Joseph, University of Minnesota, who chose men like the late J. H. Slater of Republic, the late J. S. Fulton of Ingersoll-Rand, P. F. Dolan of Bethlehem, W. E. Brewster of Wisconsin Steel, G. E. Steudel and H. A. Strain of Carnegie-Illinois Steel Corp. The War Production Board was represented by G. H. Halvorsen, P. H. Royster, and C. Williams. J. D. Sullivan, of Battelle Institute, as chairman of the process and research division, played an important part in expediting the new departure in blast furnace operation through the various departments in Washington.

To evaluate the results, it was imperative that a clear cut plan be set forth, defining all of the variables which enter into blast furnace operation. It was necessary to establish a base line. Such a period for obtaining data under low pressure operation was possible, because some of the essential equipment for high pressure operation was slow in arriving. Another important consideration was the need for an umpire to record the operating data. It was unanimously agreed that records be kept continuously around the clock. The government commissioned the Case School of Science to observe and record all data which the operating people and the process and research division considered vital. Drs. K. Donaldson and R. G. Cover of Case School placed a corps of men at the furnace plant to observe and record all data previously agreed as pertinent. This data was later released and published by the government as Contract WPB 85 entitled "Supplementary Investigation for Increasing Iron Blast Furnace Capacity."

The early results were reported in a paper read by the author before the Chicago Blast Furnace and Coke Association in October 1944, and published on p 112, 1946 Year Book of The Association of Iron and Steel Engineers after declassification by the government. These early results were encouraging enough to continue the operation, in spite of the difficulties which were encountered.

Thus the first actual elevated pressure furnace got under way on April 26, 1944 when top pressure was increased by ½ psi each day until 10 psi was reached. This furnace was continued on pressure until May 1945 when it was blown out for lack of demand. It stood idle for 14 months until July 1946 when it resumed operations. No lining repairs were necessary.

YOUNGSTOWN

The second furnace to apply high pressure was No. 3 at Youngstown. This went on in January 1946. This is a 25 ft 6 in. hearth furnace and with the exception of about 2½ months has been on pressure operations continuously.

The third furnace was the Warren furnace which started on 5.1 psi January 1948. This is another 27 ft 0 in. furnace. At the time pressure was increased the lining had 26 months of service.

The fourth furnace converted was at Chicago, another 27 ft 0 in. diameter hearth. Operations started May 14, 1948 with 5.1 psi, when on June 1, 1948 the pressure was raised to 10.1 psi. The service on the lining at the time of applying pressure was 3½ years. It now has been on this operation continuously for 16 months.

The fifth furnace to embark on pressure was No. 2 at Buffalo starting on 5.4 psi, January 1949. The hearth diameter is 22 ft 0 in. This furnace was "blown in" on July 1946 and at the time of conversion had 30 months of service on its lining. Lines of the pressure furnace are shown in Figure 1.

At this point it might be well to outline the conversion changes made at each installation. While they generally follow a standard pattern, plant layouts made

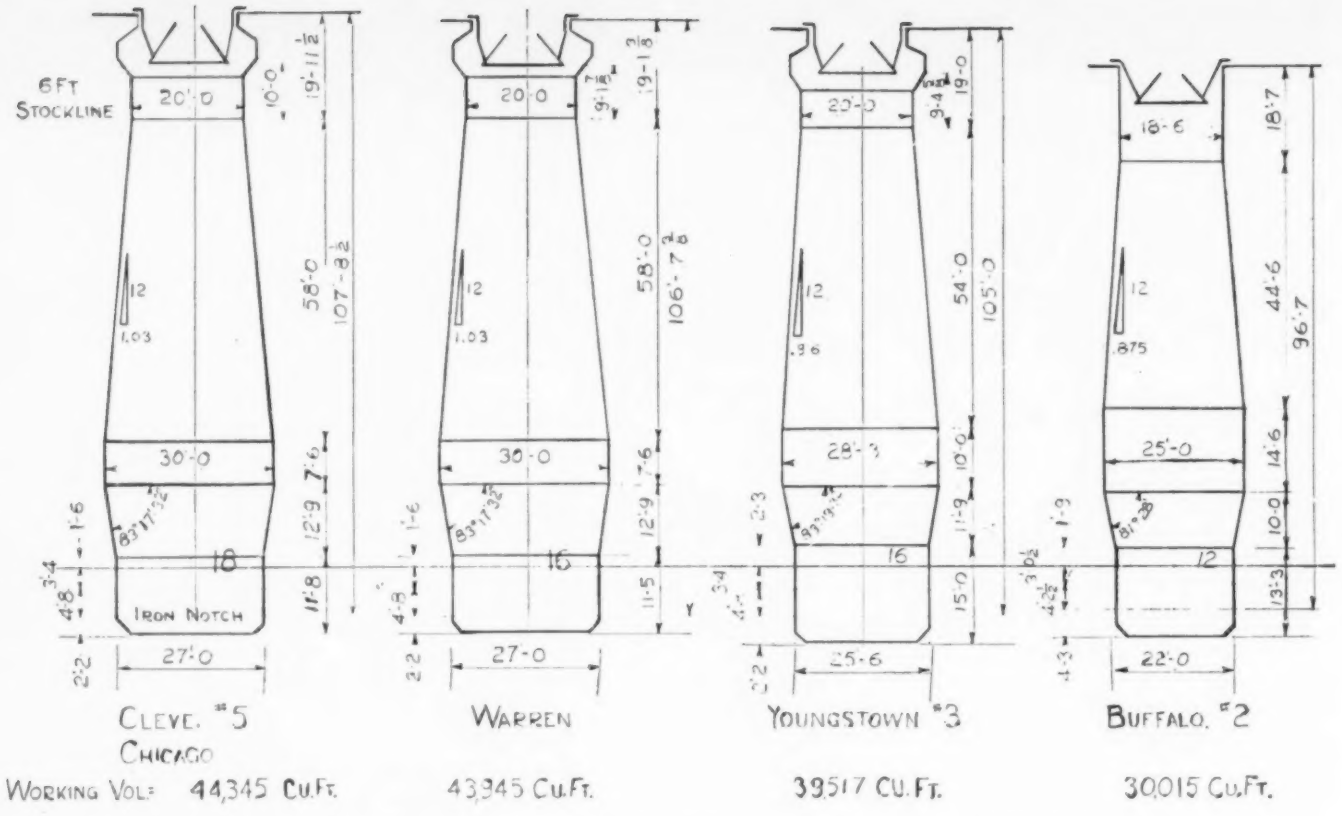


Figure 1 — The outline dimensions for some of the pressure furnaces operated by the Republic Steel Corp. are given in this drawing.

some deviations necessary. The Cleveland installation has been covered by previous literature.

The equipment which might be considered as standard, can be outlined as follows:

1. Blowing equipment able to deliver wind at the higher volume and pressure.
2. Charging equipment capable of delivering an increased quantity of raw materials to the furnace.
3. Stoves which are large enough to heat the increased wind volume.
4. Water pumps with sufficient delivery head to overcome the increased pressure. (Increased water volume required at the increased blowing rate is small due to a decrease in gas volume due to pressure.)
5. Controlled gas washer water overflow to maintain a seal in washer.
6. Automatically controlled septum or pressure controlling valve.
7. Piping for equalizing pressure above the large bell before lowering.
8. Bleeder valves of the pressure closing type on top of the furnace, opening by impulses taken from the uptakes or downcomers.
9. A clean gas bleeder line taken after the gas washer, operated by impulses from the uptakes or downcomers. This takes care of the majority of slips and rolls, relieving the dirty gas bleeders of much of their duty.
10. Keying in of bosh coolers, similar to keys used on tuyere coolers. These changes are generally as outlined in the B. S. Old paper.[1*]

In the conversion of Youngstown No. 3 it was necessary to provide a turbo-blower capable of 95,000 cfm at 35 psi. It was also necessary to provide a gas washer, as this furnace partially shared a gas washer with No. 2 furnace.

Additional stove capacity has since been added. This increase in stove capacity in this plant was necessary because of old and inadequate stoves, which were due for replacement even if this furnace had continued on normal pressure. No changes to stockhouse or charging equipment were necessary.

The Warren installation required a turbo blower capable of delivering against increased pressure. The existing blowing equipment was adequate to allow pressure operations up to 6 psi and the furnace operated at this level from January to October 1948, when the new blowing unit was placed in service and top pressure was stepped up for a monthly average of 9.8 psi. Since then the pressure has been raised to 12 psi.

The gas washer water supply was increased. Pumps were installed to deliver water at 40 psi discharge pressure at the washer nozzles. Since the new blower can deliver 125,000 cfm, the washer water requirements were calculated for this maximum. Stockhouse and charging facilities were not changed.

A 30 in. clean gas bleeder line was installed from the top of the gas washer to the top of the furnace. All bleeder valves are actuated by air cylinders. While previous bleeders were actuated by electric hoist units, cylinders have an advantage, since faster opening and

*Numbers refer to Bibliography at end of paper.

closing is obtained. The cylinders are controlled by impulses from the uptakes through a solenoid valve. The solenoid valve is normally closed, with the pressure impulse interrupting the current supply. Thus in case of power or circuit failure the bleeders would open.

In previous installations the septum or pressure controlled valve took the form of three 30 in. valves built into a unit inserted into about a 6 ft 6 in. main. However, at Warren the existing piping consisted of two parallel mains, and it was therefore possible to install 3-30 in. lines connecting the two mains, with a 30 in. valve in each line. With this arrangement it is possible to very easily change the automatic control to any valve. Two of these valves are manually preset, with the third valve doing the pressure regulating automatically.

CHICAGO

At Chicago blowing, stocking and charging equipment, stoves, washer water pumps required no alterations. This plant then required the minimum amount of alteration, for conversion.

BUFFALO

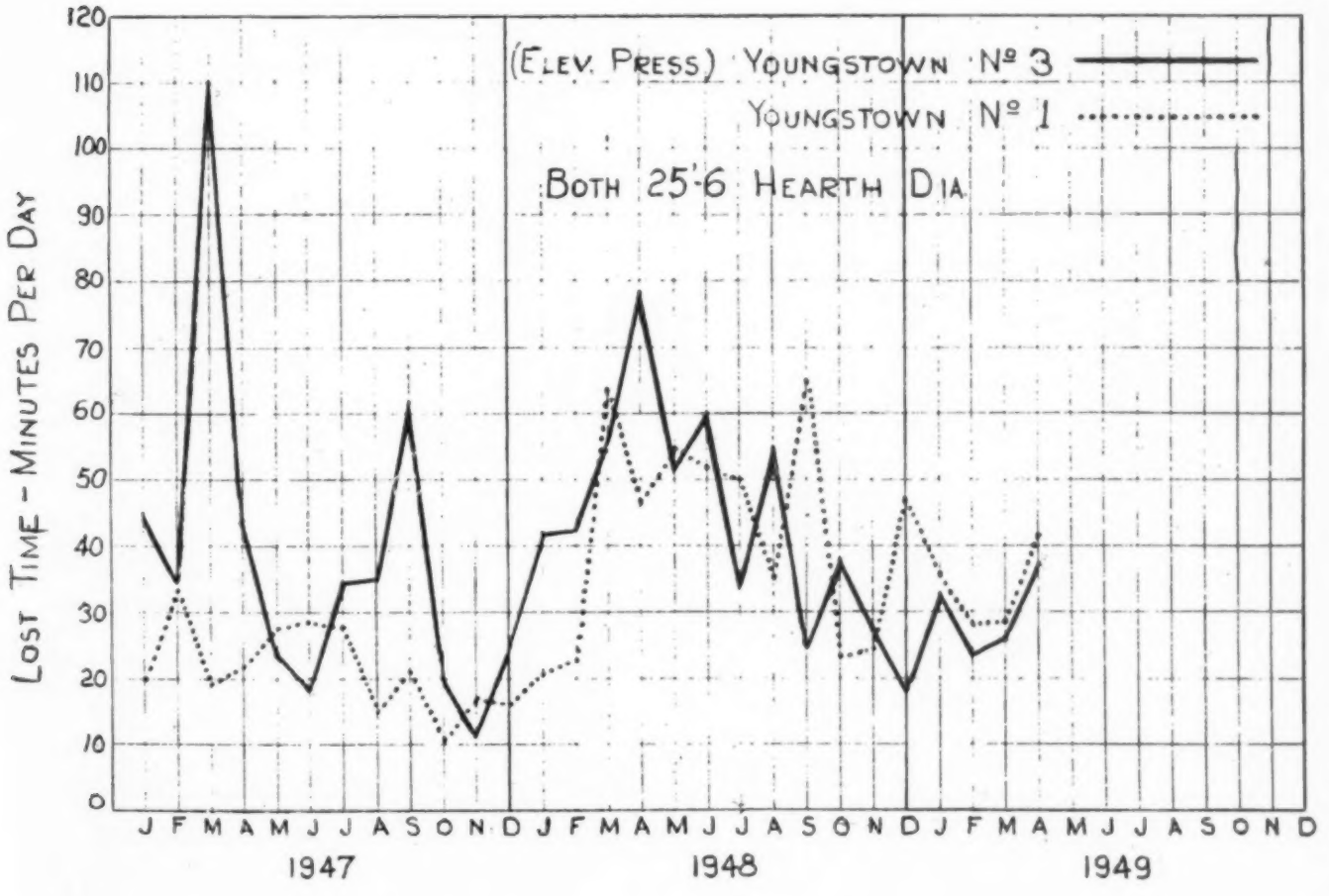
At Buffalo No. 2, a new 5-stage blower, 90,000 cfm at 35 psi, was required and installed. The intake to the blower is provided with an oil filter. The discharge end has a 12 in. butterfly, set to discharge to atmosphere automatically at any predetermined pressure. This protects the blower from excess pressure and is set at present at 33 psi. Its operation has been satisfactory. Stocking and charging equipment were adequate. Stoves were adequate in capacity, although the domes of the stoves were renewed.

One departure at Buffalo may be of interest. In all previous installations the bell operating mechanism consisted of air cylinders, however at Buffalo the bells are electrically actuated. Under this system the bell beams carry the counterweight to hold the bells and their loads in a closed position. The electric units pull the counterweighted beams to the open position. This means that in the event of any failure of the pressure equalizing between bells, these electric units had to be protected against trying to pull the bells open. This is just opposite to what would occur with air cylinder operation, which under this kind of failure would result in slack bell cables and is protected by simple slack cable switches.

This problem was solved by retaining the electric units and installing a fluid drive between the bell hoist and motor. This fluid drive slips under excessive load and no damage can occur. This installation is satisfactory.

It is also interesting to note that the Buffalo gas

Figure 2 — After the initial operational bugs were taken out, operational delays on high top pressure furnaces have been reduced to a point where they are comparative with ordinary furnaces.



washers have superimposed electric precipitators. The pressure regulating valve is placed in the gas line after the precipitators. The precipitators operate under the full top pressure, with the result, that the efficiency of the precipitators handling the heavier gas, had increased. A cleaner and drier gas for equalizing is obtained than can be had from primary washed gas.

Due to a tap hole breakout in December 1948, the furnace has operated with two of the tuyeres at the tap hole plugged. The operators feel that this furnace operating on only 10 tuyeres, would have been rough at the best were it not for pressure blowing.

Incidentally it might be pointed out that in the original pressure installation it was proposed to regulate after the precipitators. This was abandoned at that time because the precipitator seals were too close to the ground and not enough space existed between the electrodes and the water level in the precipitators.

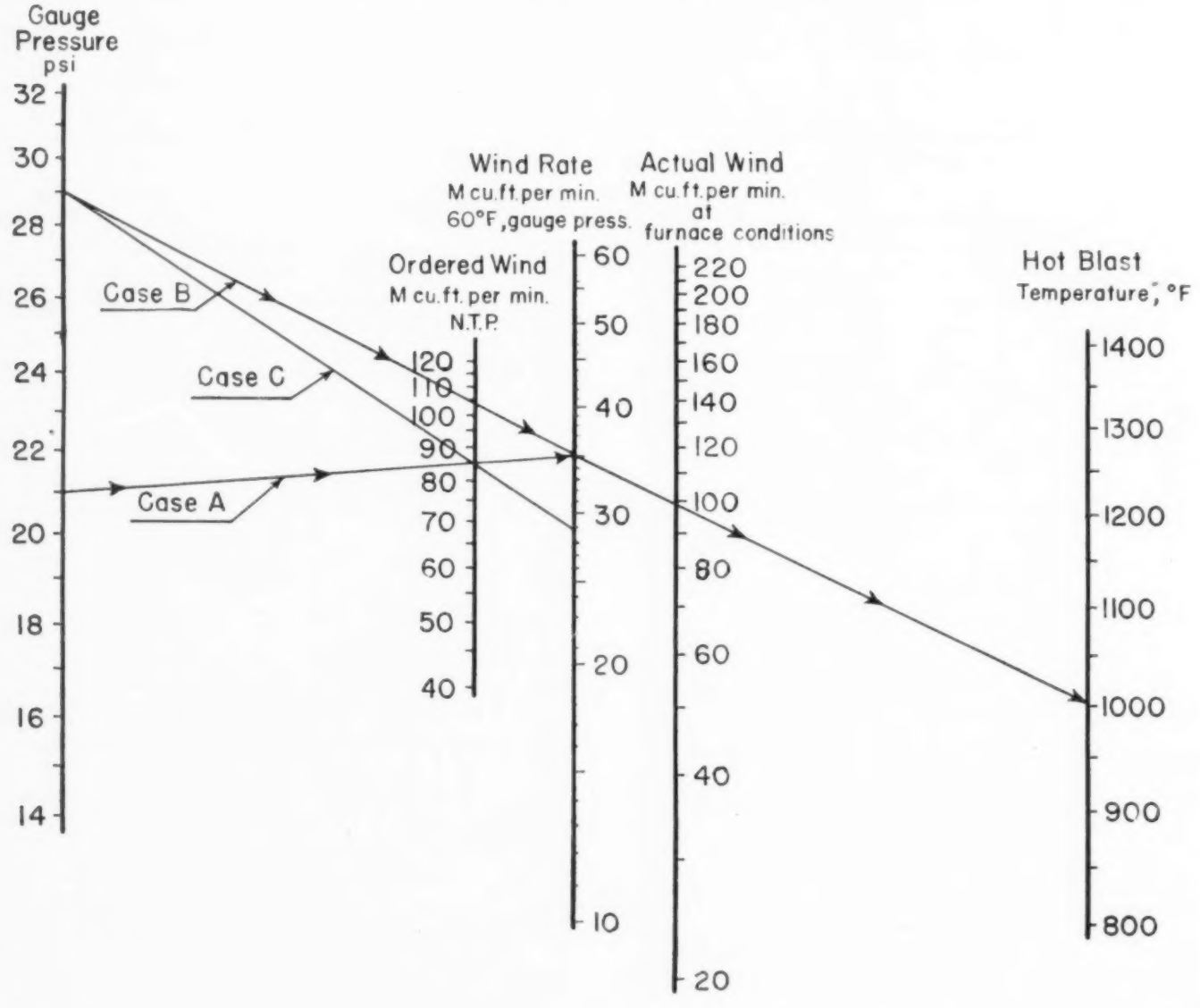
The erosion of the large bell seat and hopper at Cleveland No. 5 in the fall of 1944, started a whole chain of events. This was a multi-piece hopper and it was evident that some of the wear was due to the joints opening slightly. As a solution, J. H. Slater proposed a hard surfaced seat on the bell and hopper. A hopper with a 7 in. wide seat and a bell with a 10 in. wide strip of hard surfacing made with Stoody No. 6 was installed in early 1946. This bell and hopper are still in the furnace and had operated at 10 psi or better for two years before any erosion of the seat was observed. Since then it has continued on 5 psi satisfactorily.

In June 1946, another means of effecting a seat was tried at Youngstown No. 3. This consisted of a groove in the hopper seat, into which was inserted a special water cooled plastic tube. This functioned less than a week, and since another tube was on hand, it was decided to repeat the experiment, when the bell and hopper, minus plastic seal failed to hold pressure. Therefore 13 months later a second plastic seal was installed. This confirmed the results of the first installation, and this idea was abandoned.

Since the hard surfacing was apparently giving a satisfactory account of itself, it was therefore used in subsequent installations.

The service obtained on a plain bell and hopper after

Figure 3 — This nomograph can be used to show the effect of pressure operation on the volume under various conditions of temperature and pressure.



the plastic no longer functioned led to the belief that the hard surface on the bell could be reduced from 10 in. to two 1½ in. wide bands. This application of hard metal was tried on the next four bells. The early results indicated that we were getting some leakage past the seat. This started a study of bell seating operations, and it was found that a large bell will not make a good seat about 10 times out of 100 closings. This followed no set pattern, fifty dumps might be perfect, while the fifty-third, fifty-sixth would leak or on the next 100 counts the twentieth would leak and the next 20 would be perfect. However, it was observed that on a reverse round, where coke was put on the bell first, a poor seat is more likely to occur. It was apparent that under these conditions a leak might extend over a considerable period of time, depending on variables in charging. When a poor seat occurred, it was noted that the build-up of pressure between bells was very rapid.

A method was devised to automatically handle the bell. This consists of altering the charging control to include a pressure switch connected to the gas seal. A time interval is allowed for this build up. If pressure develops within this period, the large bell is dumped again automatically. If none occurs, charging continues in the normal manner. This of course requires keeping the relief valve closed after the big bell dump. This interlocking of the charging control with pressure between the bells, will extend the life of the bells considerably. Previously the only evidence of a leaky condition was failure of the small bell to open. It is felt that this method of handling the bell will prove that an ordinary unhardened bell and hopper can be used and will stay in service for a campaign on a lining.

Still another method is being tried at Warren. There pressure is introduced above the large bell after each dump of the small bell. In this way pressure differential across the big bell seat is low most of the time. It was thought this method would introduce difficulty with the distributor packing. However, this has not materialized and reports to date are favorable. This method has the disadvantage of using more gas which is lost to atmosphere with each small bell dump.

It might be well at this point to mention that equalizing between bells was first accomplished with raw dirty gas. All installations today use primary washed gas for equalizing as well as bleeding to relieve the equalizing, relief valves and dirty gas bleeders of wear.

In the report of 1944 a chart showed lost time or delays of operation. At that time it was recognized that unless delays were brought in line, pressure blowing could not be economical.

Figure 2 shows that subsequent developments and improvements in operating technique have reduced delays to a normal level.

It might be well to review safety features incorporated in pressure installations. Since this operation requires bleeder valves which are held closed by pressure and must be pulled open, it must be recognized that a power failure of an electric unit would prevent their opening. Therefore, electric units are being replaced by cylinders and as stated before are controlled by solenoid valves which open when power is off. However a cable to the bleeders might break and while it is improbable that all cables would fail simultaneously, it is felt additional safeguarding should be provided. Impulse lines might fail. Therefore, a counterweighted bleeder is placed on top of the gas washer, weighted to a higher pressure than the furnace bleeders. However, even this does not protect against the possibility of the gas washer filling with water, in which case the counterweighted bleeder on the washer would be inoperative. A counterweighted bleeder has recently been installed on one of the furnace uptakes at Warren. This bleeder is weighted to 20 psi. It is too early to report how this valve will stand up under service.

Figure 3 is a nomograph which was prepared to show the effect of pressure operation on the actual volume, under varying conditions of pressure and temperature. It will be noted that under the case "A" conditions, 85,000 cfm at normal temperature and pressure, reduces to 35,000 cfm under 21 psi gage blast pressure.

Then if top pressure is so increased as to increase the blast pressure to 29 psi gage, 105,000 cfm at normal temperature pressure conditions can be blown, which reduces to 35,000 cfm. Thus the velocity entering the tuyeres remains the same in both cases. To accomplish this requires an increase of top pressure in the magnitude of 10 psi.

Thus 20,000 cfm additional wind can be blown without altering either the buoyancy of the stock or the chemical heat balance. This 20,000 cfm is a 23½ per cent increase in oxygen going into the furnace. But since 23½ per cent additional nitrogen is also introduced, the heat exchange capacity between hot gases and burden remains the same as case "A," provided 23½ per cent more coke and burden are made available. Any change in hot blast temperature increases the volumes to the same end result, whether starting with 85,000 or 105,000 cfm at normal temperature pressure conditions. This clearly shows why increased tonnages are possible with pressure operations.

Now suppose we examine case "C." In this, we blow 85,000 cfm but at elevated pressure, again say at 29 lb gage. The result is that while the same amount of coke destroying oxygen as case "A" enters the furnace, it is moving at a slower rate. It has been proven beyond a doubt that slow blowing results in a lower coke rate.[2]

Therefore, it is apparent that present pressure blowing technique can be used in three ways. When demand for iron is high and coke economy is not as important, wind can be increased for maximum tonnage. When economy of operation is paramount, coke can be saved by reduced wind at increased pressure or some intermediate between these two can be used. Above "present" pressure blowing technique is stated because there is nothing in the past five years of experience that indicates that additional benefits cannot be had by further increases in operating pressures.

While the author is at present interested only in reporting the results and progress made since 1944, the possibilities of extending the operations beyond those so far experienced, must be pointed out since they offer a challenge to the blast furnace fraternity.

Several years ago Owen Rice[3] published a formula for arriving at the gas retention time in a blast furnace.

$$T = \frac{\frac{0.36V}{167 \times \text{lb coke/day}}}{86{,}400}$$

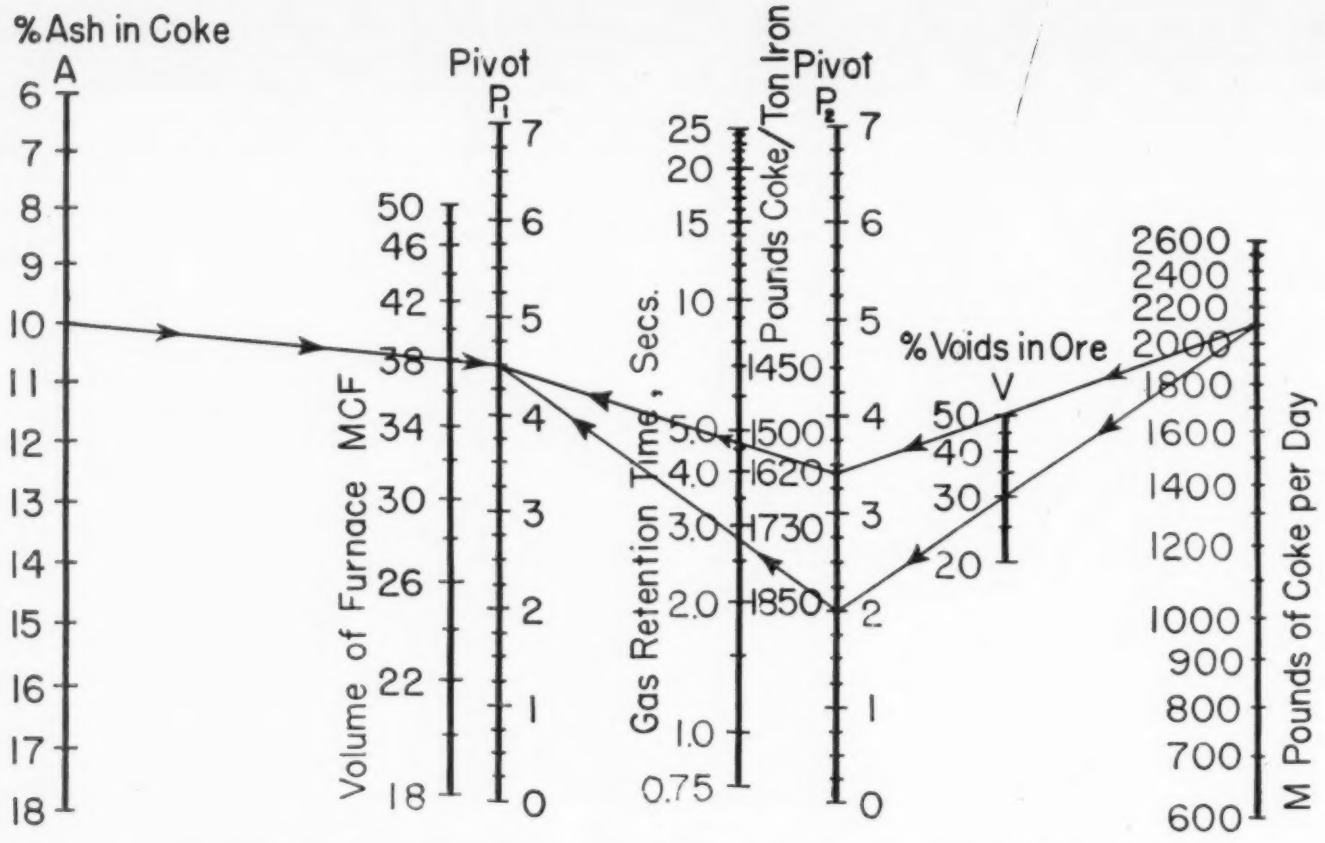


Figure 4 — The "Gas Retention Time" can be calculated by this nomograph which is based on the equation given by Owen Rice: $T = \frac{FV}{C(100-A)}$

V = Furnace Volume — T = Time in Seconds
0.36 = Probable Voids — 86400 = Seconds per day
167 = Cu ft gas per lb of 88.5 per cent fixed carbon coke at average pressure and temperature throughout the furnace.

While this formula took into account the working volume of a furnace, and the ability of a given hearth diameter to consume coke, it assumed values for voids in the burden and fixed carbon in the coke. To make it easy to substitute various values and see their effect, this formula was made in nomograph form and is shown on Figure 4. The limits of fixed carbon in the coke are from 72 to 94 per cent working volume from 18,000 to 50,000 cu ft, coke consumed per day from 600,000 to 2,600,000 lb.

The reason for interest in this formula was to study its application to elevated pressure theory and results. From this nomograph the lowering of linear velocity as shown by Slater[4] can be readily studied.

It will be noted that a furnace using 2,000,000 lb of coke per day, with 30 per cent voids in the burden, a 10 per cent ash coke and 38,000 cu ft working volume, will calculate a gas retention time of 2.8 seconds corresponding to a coke rate of 1750. However, if in some manner the burden can be opened up to a 50 per cent void basis, the gas retention time is 4.6 seconds corresponding to a 1560 coke rate. Net result is a saving of 190 lb of coke per ton of iron. This is about what happens when on elevated pressure operation.

To accomplish longer gas retention time, three methods are available:

1. Selective charging of particle sized material, which increases voids.
2. Pressure operation, which reduces the volume of gas for a given wind rate.
3. More working volume above the tuyeres.

From this chart it can be seen that an increase in working volume from 38,000 to 42,000 cu ft will result in a coke saving, but only on the order of 50 lb per ton of iron. It can also be seen that a decrease in coke per ton results from increasing the working volume above a given hearth as has been demonstrated quite conclusively in a number of plants.

Therefore, by using Owen Rice's formula in graphic form a convenient means is provided of readily grasping what occurs under any given set of operating conditions. While the coke rates given by this formula are on the low side, it would indicate that the percentage of voids in the burden are less than the presently assumed values. Further study of burden voids correlated with actual operating results would be helpful.

The ability to charge raw flue dust back into the furnace when on reduced wind and pressure, is well worth mentioning.

Chicago in August 1949 blowing 50,300 cfm, charged 284 lb and produced 53 lb, or a net gain of 2600 tons of flue dust, without a sintering charge, which is an excellent way to reduce flue dust inventories.

At Buffalo No. 2, flue dust per ton of iron in the years 1947 and 1948 was 139 and 127 lb, respectively. Since January when pressure operations started, the flue dust has dropped to a low of 41 and a high of 80 for an aver-

age of 63 lb per ton, and this is with flue dust being recharged.

Iron produced under elevated pressure operations during the past five years is as follows:

Cleveland No. 5	1,300,000 Net tons
Youngstown No. 3	1,150,000 Net tons
Chicago	425,000 Net tons
Warren	700,000 Net tons
Buffalo	200,000 Net tons
Total	3,775,000 Net tons

Therefore, at the time of publishing this paper, well over 4,000,000 net tons will have been produced. While this is a small percentage of the total iron produced in the country in the last five years, it is a remarkably good start, and as the technique spreads to more furnaces, an important step will have been taken toward providing a reserve capacity and the efficient use of coke.

Two more furnaces at our Youngstown plant will be equipped for pressure operations in the near future. One other furnace in this country is now equipped. This then is a total of six furnaces and with the two additional at Youngstown will make a total of eight in the U.S.A.

In addition, I understand that the British expect to have one operating on pressure in the very near future.

It is gratifying to see that progress is being made, and it has been a pleasure to work with the operators and engineers whose understanding of the basic principles made possible the pioneering spirit so necessary to overcome the handicaps encountered.

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DISCUSSION

PRESENTED BY

L. E. RIDDLE, Consultant, Laclede Christy Co., Pittsburgh, Pa.

FRANK JANECEK, Blast Furnace Engineer, Republic Steel Corp., Cleveland, Ohio.

P. E. HAGLUND, Supervisor of Engineering, Ford Motor Co., Dearborn, Mich.

C. W. DAUBERT, Chief Combustion Supervisor, Allegheny County Smoke Control Div., Pittsburgh, Pa.

K. C. McCUTCHEON, Assistant to Vice President, Operations, Armco Steel Corp., Ashland, Ky.

L. E. Riddle: There is one thing the author should mention, and that is what they have gained in tons and lower coke. I am wondering if at any time on these furnaces they have taken off the high pressure and gone back to normal for a period to prove for themselves just what increase you get in tonnage and in lowering coke. You did mention that your flue dust dropped from 160, I believe you said, down to as low as 193 to 41?

Frank Janecek: From 193 to 41.

L. E. Riddle: Have you ever made a check of a furnace with the top pressure and then run for a period without it to see just what increase in tonnage you get and what lowering of coke with high top pressure?

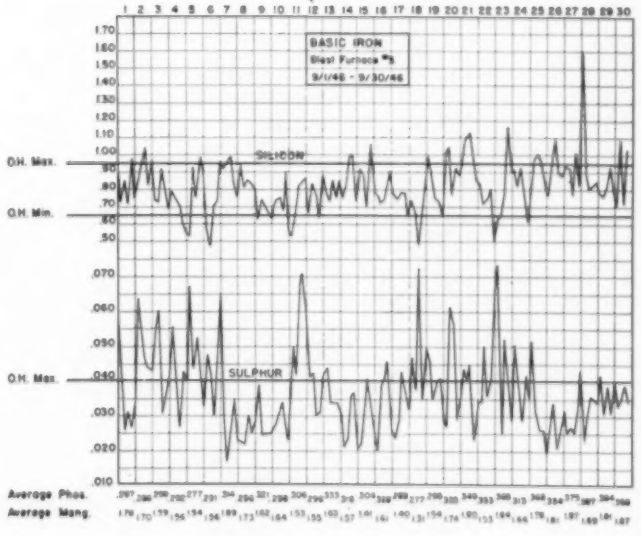
Frank Janecek: In the early part of the paper I said it was necessary to establish a base line. That was done in the beginning when the furnace was operated on 100 per cent ore, with no sinter, and no scrap. That was our base line. It was necessary to do that to evaluate the operation, otherwise there would have been no way to know what the gain was.

I will say this, that while the industry in general has produced less tons per square foot of hearth, on the pressure furnaces, we are holding pretty generally to what we did six years ago on the materials available at that time. I can say also that, at considerable expense from an operating standpoint, that test was made on 100 per cent ore burden, when it would have been much more economical to produce tonnage from scrap materials that were available at that time at lower prices than the ore, so that a base line could be established, and that base line is being used in projecting other pressure-operating furnaces.

Now, as to the increased tonnages, it is possible to get about 15 per cent increase in tonnage. It is also possible to get a reduction of coke of better than two hundred pounds, and it has been done many times.

Pressure operation is not something that the operator can just put on the furnace and walk away and

Figure 5 — The silicon swings are concentrated in a smaller range on the pressure furnace as is illustrated by these operational curves which give the variation in silicon and sulphur over a one month period.



expect it to run. He has to use the same intelligence that he does on a normal-operating furnace.

P. E. Haglund: My sympathies are still with the open hearth department and I expect there are a lot of other open hearth men who are vitally interested in the silicon swing of blast furnace iron. At times it varies as much as 2 per cent in a single day. How to use iron of this kind certainly sets up an open hearth problem. Would higher blast furnace pressures have a tendency to smoothen out the silicon curve?

Frank Janecek: As a matter of fact, our silicons have usually been much more within the specifications on the pressure furnaces than they are on nonpressure furnaces, because the swings are not there; the furnace moves much more smoothly and there are no severe swings of silicons.

Our specifications are from 0.65-0.95 which is a rather narrow band. They are plotted every month. I can definitely say that they are much more within the limits of the specifications. Figure 5 shows a silicon-sulphur curve for one month.

C. W. Daubert: I should like to ask Mr. Janecek whether he has observed any difference in the number or intensity of slips between pressure blowing and regular blowing.

Frank Janecek: Yes, there is some slight decrease in the amount of slips, but that is incidental. The point I think you are primarily interested in is the fact that we no longer permit the dirty gas bleeders, which are on top of the furnace, to carry the bulk of the slips. We take a 30 or 36 in. gas line from the gas washer back to the furnace and put a bleeder valve on it. The impulse to it comes from the same uptake that the dirty gas bleeder operates from; therefore, on a slip or roll, the clean gas bleeder opens before the pressure wave gets through the system and therefore the dirty gas bleeders do not operate except very rarely; we therefore are bleeding only clean gas. See Figure 6.

This is a system that should be put on every blast furnace, regardless of whether it is on pressure or not on pressure, because it helps clean up the neighborhood. I might say also that we are following that system on the four furnaces in Cleveland that are not on pressure blowing. Plans are on the board, material is being procured for just that type of operation on the nonpressure operating furnaces in Cleveland.

C. W. Daubert: The reason I asked the question originally is that we had some information, and I do not know where it came from at the moment, that the high pressure operation decreased the number of the slips, and I wondered if you had been able to prove anything in that line.

Frank Janecek: The number is definitely decreased, but the number does not make too much difference. I was out in our Chicago plant a couple of weeks ago. It is customary there to check the bleeders once a day to see whether they are operating, and that probably takes about a minute, so that the dirty gas bleeder is open for something less than a minute. The operator told me that five minutes after he tests the bleeder, the telephone rings and someone says, "What is the matter with your blast furnace? You are covering the community!" Apparently someone has a pretty close eye on those operations, and as soon as a dirty gas bleeder

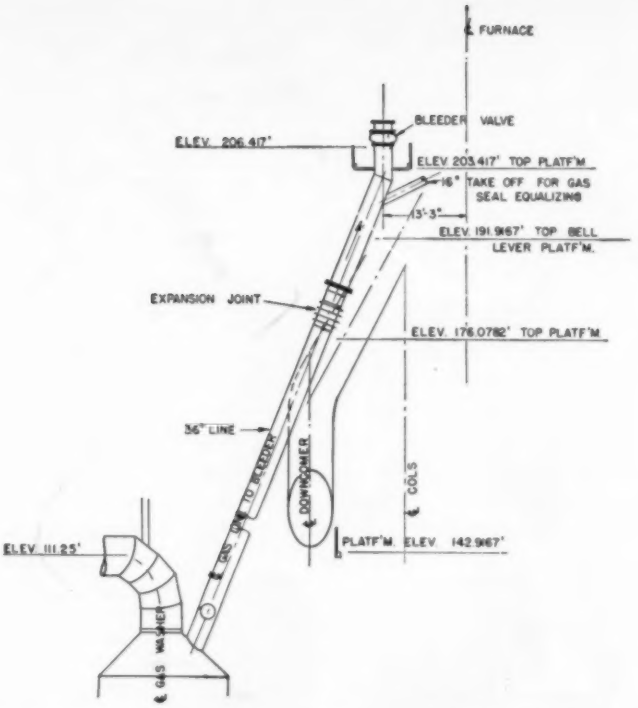


Figure 6 — This sketch shows the layout of a 36 in. clean gas bleeder line from the wet washer to the furnace top.

opens, they want to know why. The important thing is that while there is a decrease in the number of slips in the furnace, the dirty gas is not being bled to the extent it was formerly.

K. C. McCutcheon: I should like to ask Mr. Janecek about the remark he made on the Cleveland furnace now being operated on five-pound pressure instead of ten. Is that because the bell leaks, or for some other cause?

Frank Janecek: That is because after twenty-six months of operation on ten psi or better, the bell did develop a leak, and rather than continue on ten psi pressure, the pressure was cut down, because there was no bell available to put in its place. At that pressure it has been operating for a year.

K. C. McCutcheon: Would it be possible to make any comment as to the comparison of results? That would answer to some extent the question: "What are the results comparing no pressure, some pressure, and high pressure?"

Frank Janecek: After you pass five psi, there is a remarkable decrease in the amount of flue dust and a decrease in the coke per ton.

K. C. McCutcheon: I was interested in the remark you made about the study of the bell. On the large bell you had 10 per cent bad seating.

Is that ten out of a hundred, with bad seats? Further, if you had a reverse charge, it was rather evident that did cause bad seats; in other words, when charging the material on the bell in the opposite direction, you did get bad seats?

Frank Janecek: Yes, with coke on the bell first, a poor seating of the bell under low pressure operation is not serious, however under high pressure it is. That is why the new method of handling the bell protects against starting the filling on a leaking bell seat.

Implications in High Speed Heating

FOR THE STEEL INDUSTRY

By FREDERIC O. HESS
President
Selas Corp. of America
Philadelphia, Pa.

. . . . developments in high speed heating indicate that new practices and techniques will be adopted in the not-too-far-distant future by the steel plant operator . . . .

▲ DURING recent years processes utilizing accelerated rates of heating metals, steel in particular, have been introduced in industry. The term "High-Speed Heating" has been applied because so far the difference in heating time has been considered as the most important distinguishing factor. To lay a proper foundation for the subsequent remarks it might therefore be in order to specify, at the outset, that the high-speed heating techniques covered by this paper utilize gas as fuel, and that heating rates from one to five minutes per inch of thickness are referred to here as speed heating—in contrast to the conventional practice of one-half to one hour per inch of thickness.

Obviously, to obtain such heating rates, different heating techniques as well as different equipment and handling methods must be applied. Uniformity of temperature application is essential as well as high temperature exposure. Heating chambers, or furnaces, must be of different construction to withstand the high gradient temperatures of 2500 F and up, and to provide uniformity of heating.

Temperature controls face unique problems when applied to high-speed heating installations but, also, substantial improvements and benefits might be brought about if new control methods are devised and adopted.

A brief review of a variety of actual installations and results will indicate clearly the requirements and the factors which influence performance:

Figure 1 shows a typical installation of high-speed heating equipment for continuous annealing of stainless steel bars or tubes. To facilitate handling, a variable speed roller conveyor is employed, and the heating chambers themselves are sectionalized, keeping the conveyor equipment outside the heating zones. These heating zones are contoured and burnered to suit the shape of the work piece. In other words, we have a series of horizontal barrels surrounding the pipe, tubing or bars during passage and heating is by both radiation and convection from properly spaced high temperature radiant burners.

For stainless steel annealing, a spray quench is applied immediately at the outlet of the last heating zone, and typical results from an installation of this type are illustrated by the photomicrographs on Figure 2, picturing 303 stainless steel before and after annealing.

To prove the effectiveness of the short heating cycle, a bar of austenitic stainless steel was sensitized by holding at 1500 F for five hours. This treatment produced an excessive concentration of carbides in the grain boundaries, as shown in the left photomicrograph. Heating from cold to 2000 F annealing temperature in slightly less than three minutes per inch of thickness, the carbides were completely placed in solid solution, as evident in photomicrograph on right.

Installations of this type are in operation, annealing tubing in the size range from $\frac{3}{8}$ in. outside diameter, 0.020 in. wall, up to 9 in. outside diameter, with 1 in. wall; and solid bars up to $3\frac{1}{4}$ in. diameter.

Two types of temperature controls have been employed: one operating on the fuel input as the material reaches final temperature; the other to change conveyor speeds automatically for any variations in the

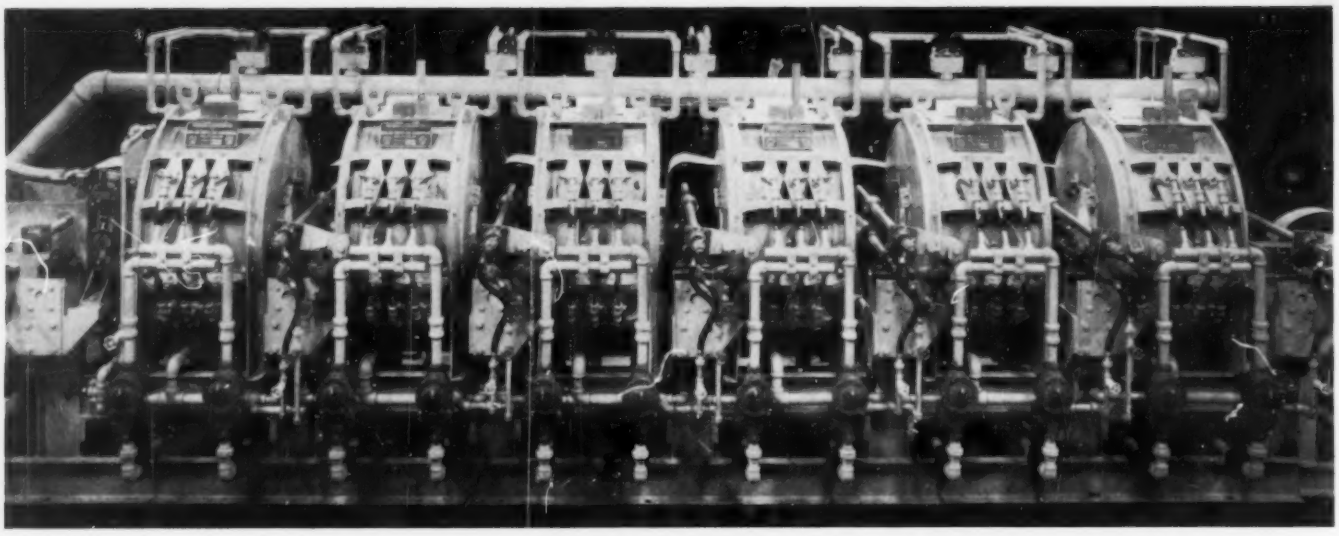


Figure 1 — The equipment shown is a typical high speed radiant gas heating unit for the continuous annealing of stainless steel bars and tubes.

tube or bar temperature. In both cases, temperature readings are obtained directly from the metal, by optical pyrometers, rather than from furnace itself. Control instruments as well as control valves have to be designed for exceedingly rapid reaction.

Very similar equipment is suitable and is being used for the heat treatment of carbon steel bars. In this case, the quench is followed immediately by another line of furnaces of similar construction but lower capacity, to draw the heat treated stock after quenching. It is interesting to note that a 4140 type of steel, heat treated in that manner, has shown a proof stress of 140,000 psi, and a tensile strength of 152,000 psi. On normal steel of similar tensile strength the proof stress is only 115,000 psi and the tensile strength would have to be raised to 180,000 psi to obtain 140,000 psi proof stress. At this point the steel is too hard for machining.

In another case the substitution of a low-cost carbon steel for a higher cost alloy steel has been made possible by continuous heat treatment, hardening, quenching and drawing—all in one process. It involves the production of oil well casing up to 9 in. diameter x ½ in. wall, up to 50 ft in length. The conventional steel quality and specifications call for N-80 type steel of 100,000 psi tensile strength x 80,000 psi yield strength.

Figure 3 shows the micro structure of continuously heat treated H-40 type steel (of lower manganese and no molybdenum content in contrast to N-80) which has been successfully substituted because of equal physical characteristics, tensile, yield and elongation values.

Close and coordinated control of heating uniformity, heating rate and quench-rate is obviously necessary to obtain these results.

Figure 2 — Photomicrographs of SAE type 303 stainless steel bars. On the left is shown a hot rolled bar sensitized at 1500 F for five hours and furnace cooled to 1100 F. On the right is shown the same bar after high speed annealing illustrating the disappearance of the grain boundaries. The magnification is the same in both cases. The magnification as printed is about 500 X.

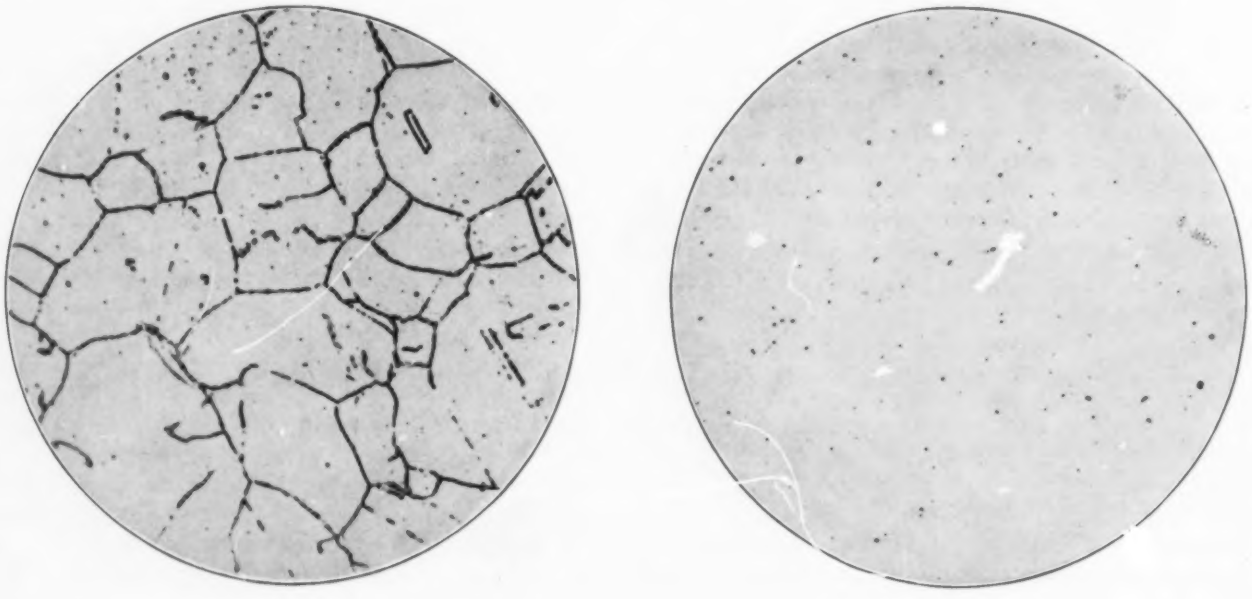


Figure 4 illustrates a typical heating-up rate to hardening temperature, as well as the extremely rapid quench, with a specially designed annular quench ring. In a matter of four seconds, the thermocouple, ⅛ in. below the surface, showed complete quench out. More than 100,000 tons of this carbon steel casing have been produced and put into service, which should confirm the success of this high-speed heat treating process.

Not the least important of the many factors affecting seamless tube manufacture is the temperature and the temperature uniformity of the tube as it enters the final sizing mill. Surface conditions as well as tolerance are affected vitally. A typical installation for reheating seamless tubes prior to sizing is shown on Figure 5. This installation was designed and constructed to reheat tubes from 1300 to 1900 F in a single pass through the line of furnaces while traveling at maximum speed of 240 fpm for the smallest tube of 2⅜ in. diameter x ⅛ in. wall, and at proportionately slower speeds for tubing ranging in size up to 9 in. diameter x 1¾ in. wall.

These speeds not only call for high rates of heat releases—high-speed heating—but call for an extreme flexibility of control because the tubes enter the furnace line with non-uniform temperature from end to end, and should leave at an elevated temperature, uniform from end to end. To accomplish this and automatically take care of the various sizes and wall thicknesses which are handled in a single mill, the entire installation is controlled by optical pyrometers focused on the tubes as they pass between the furnace sections. Also, each pair of furnaces has its own anticipating control. That is, if an approaching tube or section of a tube is at a lower temperature than called for, the following furnace is instantly put on a higher heat release basis. Then, it is just as quickly throttled again to a lower setting if the tube section passing before the optical pyrometer shows that it is at the required temperature. All of this must take place in split seconds because of the aforementioned tube speeds which, at the maximum, allow only approximately one second in each furnace section. Such an automatic control method can therefore not only balance variations in tube temperature along the length of the tube but, also, can automatically take care of different tube sizes and tube walls without overheating, or without delivering a tube which is not up to temperature to the sizing mill (within the capacity of the installation of course).

Some of the most interesting effects of high-speed heating have been obtained with solid bars, square or round, heated to rolling, piercing or forging temperature. Figure 6 illustrates an installation constructed for the purpose of heating two solid bars up to 4½ in. in diameter to a temperature of 2250 F in continuous pass, the bars being carried on dual rolls between the sectionalized furnaces.

Figure 7 is an interesting photograph of the hot bars leaving the last furnace chamber.

In order to assign a rating to one of these installations, it is necessary to know the differences in heating rates for the various steels, particularly between carbon and stainless steels. Figure 8 illustrates two typical heating curves; one for stainless billets and one for carbon. In each case two thermocouples were inserted; one in the center of the billet, the second ⅛ in. under

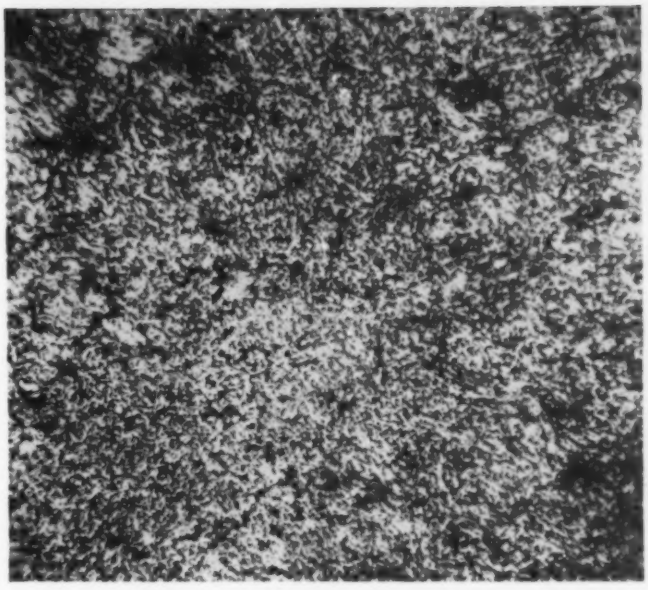
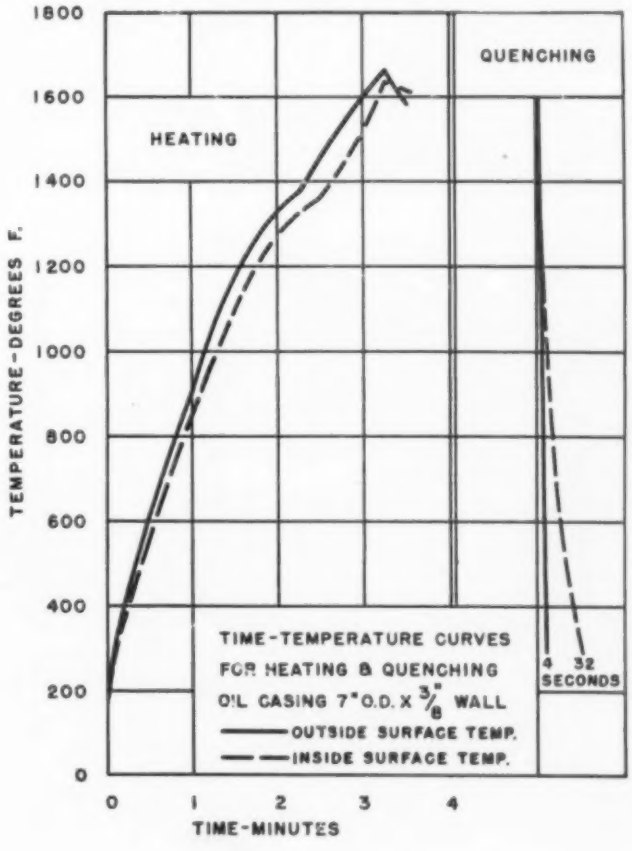


Figure 3 — The photomicrograph shows structure of continuously heat treated API H-40 type steel.

the surface. Both bars were subjected to identical heating conditions, time cycles and speeds. It is somewhat surprising and interesting to note that the stainless steel bar actually comes to temperature faster. However, this might be explained by the influence of the critical range retarding the carbon steel, as can be seen

Figure 4 — Curves are given for typical time-and-temperature relationships in heating and quenching oil well casing during continuous radiant gas hardening process.



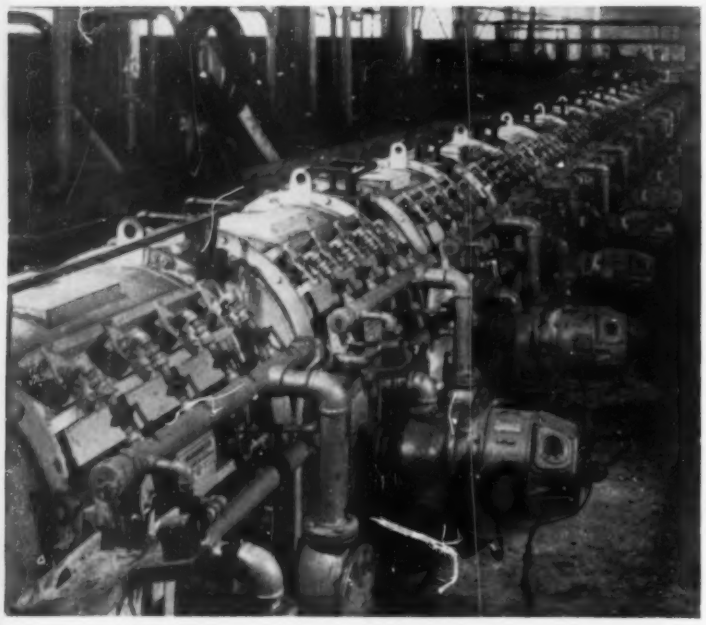


Figure 5 — The high speed radiant gas installation illustrated is used for reheating stainless steel tubing prior to final sizing. Uniform tube heating from end to end and from tube to tube is accomplished in this line at a maximum rate of 240 fpm.

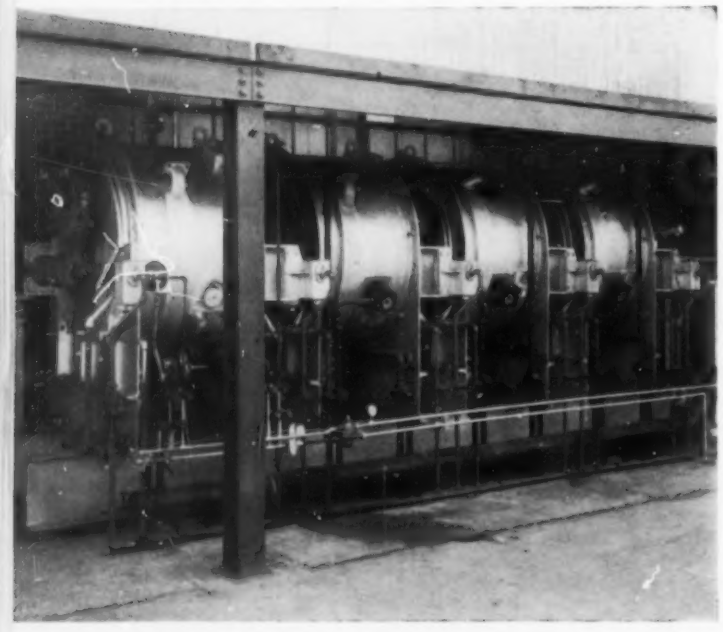
readily on the chart. In this case it can also be noted that the heating rate is approximately two minutes per inch.

Carefully conducted tests also have been performed with so-called sensitive steels. For example, Figure 9 illustrates the metallurgical structure of a 4340 steel bar 4½ in. square before and after heating. No signs of surface or internal cracking were discovered, and similar results were obtained with billets as large as 6 in. square, heated at similar rates.

To investigate surface effects, 1040 steel bars, turned and ground on the outside to eliminate any scale or decarb resulting from previous operations, were passed through the same process. Figure 10 shows the surface condition of this bar after heating and subsequent quenching for the purpose of arresting scale formation. Micro measurements and investigations disclosed that the maximum effective depth of decarb, when heating to 2250 F is 0.004 in. for 1½ in. bar, and the total metal loss due to scaling is 0.22 per cent or about one-fifth of one per cent. That is the equivalent of 0.023 lb for 100 sq in. of surface, which appears low when compared with general practice. To understand, or at least have a chance to compare the effects of slow and fast heating Figure 11 serves the purpose of showing 52100 coarse grained steel heated to 2100 F according to conventional practice, and also, heated at the high-speed rate of two minutes per inch. Both were quenched immediately after removal from the furnace. The differences in the arrested grain structure are rather striking and should have influence upon working characteristics, steel mill practice and end-product.

Any thorough survey of heating rates will, of course, have to take into account the varying emissivity factors of different metals, and they have been and still are the subjects of investigation.

Figure 6 — Bars with a maximum diameter of 4½ in. are heated to 2250 F in these radiant gas units in a single continuous pass.



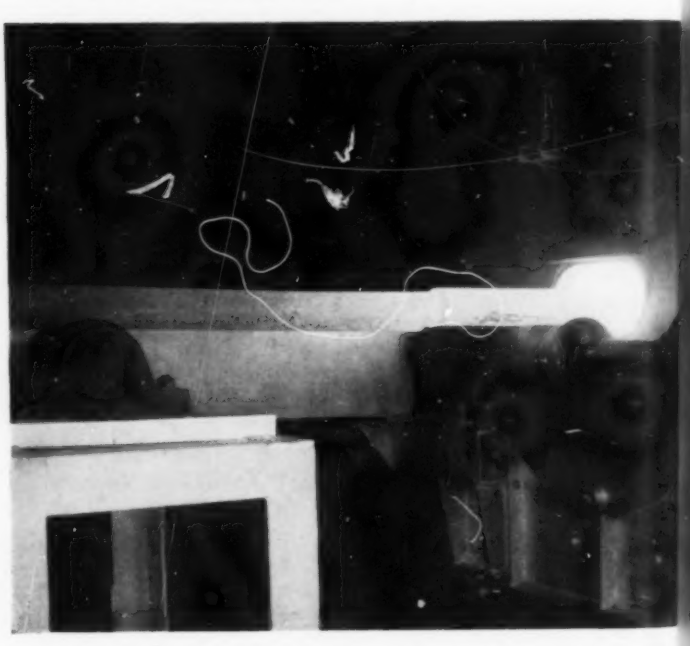


Figure 7 — Heated 4½ in. diameter bars are shown leaving the last furnace chamber of the radiant gas heating line shown in Figure 6 at a temperature of 2250 F after a single continuous pass.

Figure 12 gives a comparison of temperature as read using an imbedded thermocouple and the corresponding readings of optical pyrometers between carbon steel and 18-8 stainless steel. The differences in temperature readings are apparent and, since we must assume that the millivolt readings obtained from a thermocouple imbedded in the metal are correct, the variance of the optical readings indicate the influence of scale, surface condition and emissivity.

It would be highly desirable to have temperature measuring instruments which are beyond the influence of these factors and give us true metal temperatures, under production conditions.

The problem of temperature measurement and temperature control, as aggravated by high-speed heating, is strikingly illustrated by a project such as the fusion

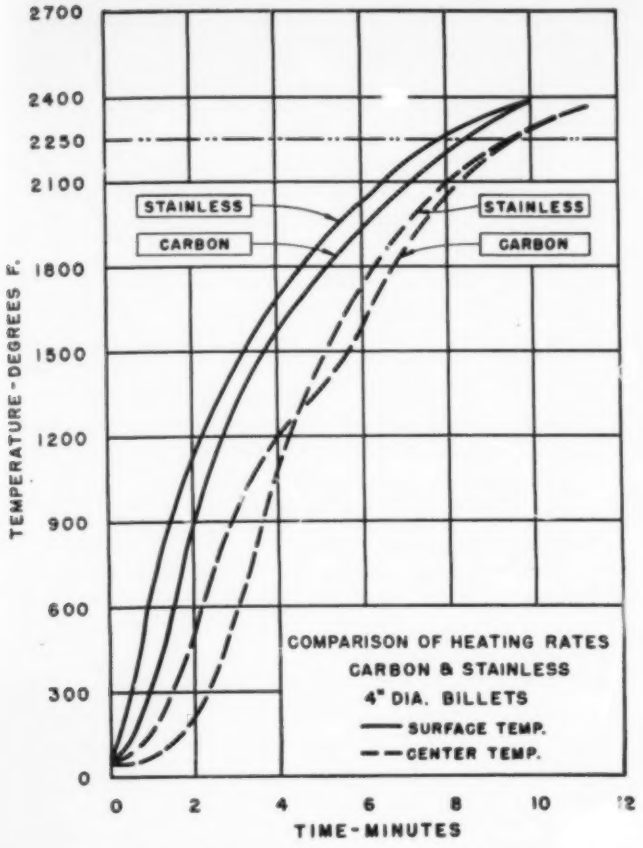


Figure 8 — Curves give surface and center temperatures of 4 in. diameter stainless and carbon billets. The curves illustrate a radiant gas heating rate of about two minutes per in.

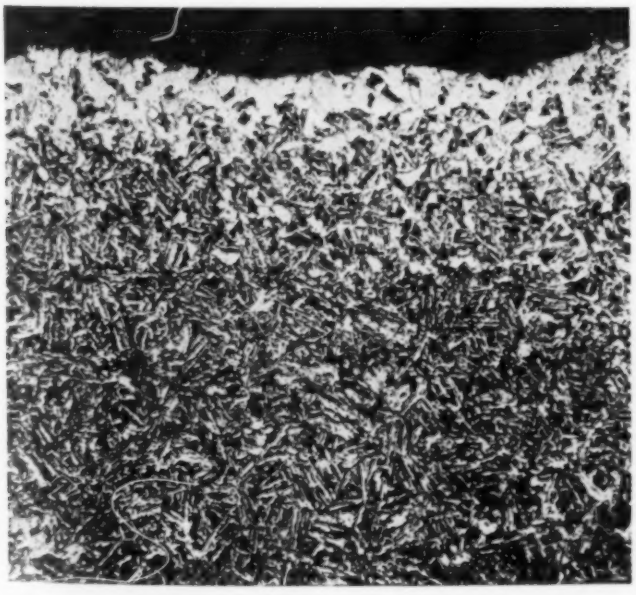
of tin on electrolytically plated steel strip at speeds up to 1200 fpm. Figure 13 illustrates diagrammatically the process as it is practiced today with the strip passing between two panels fired by radiant gas burners which heat the strip up to fusion temperature, or approximately 475 F. The heating time is in the order of 1½ seconds and therefore, for continuous operation with uniformity of production and compensations for the variations in steel strip thickness, instantaneous control of temperature is essential.

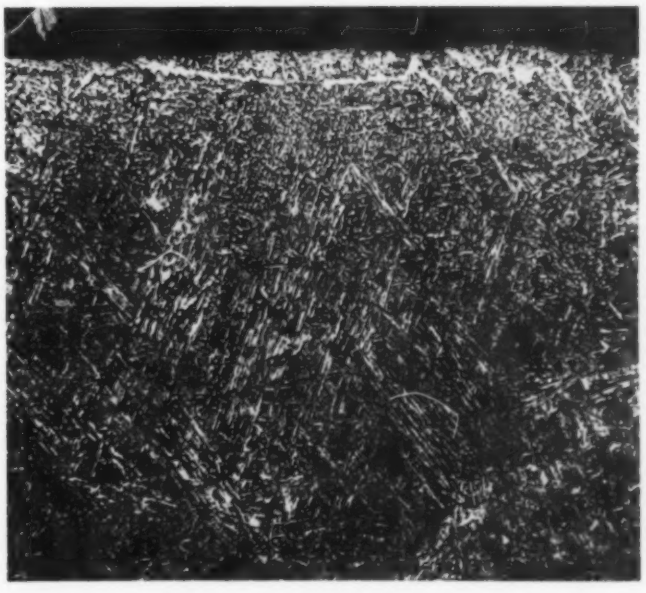
Clearly, throttling the fuel input volume, with delayed reaction on the temperature in the heating chamber and the metal temperature, is inadequate to control within the operation limits: 1½ seconds total heating time or a fraction of a second at fusion temperature with maximum allowable temperature variation on the strip at plus or minus 5 F from fusion temperature. This severe operational requirement has been met by controlling the distance from the radiant panels to the steel strip, in strict proportions, by the impulses from the optical control instrument. Practically instantaneous temperature variations are provided, apparently in accord with the square-of-the-distance effect of the radiation law. Incidentally, even the cooling water of the radiation head requires temperature control to maintain the accurate requirements of this process. This fusion is being performed at a gas consumption of ¼ cu ft of coke oven gas per pound of plate and at a maintenance cost for fusion equipment of 0.0009¢ per base box—less than one thousandth of a penny!

High-speed installations of this type and their performances indicate other applications in the steel industry which require similar accuracy and similar economy of operation.

One of the processes growing out of these experiences is the bright annealing of strip steel in a similar manner. Cold rolled tinplate stock, prior to electroplating, is passed through similar panels, as indicated in Figure 14, and heated to annealing temperature at such a speed that the products of combustion from the radiant panels do not oxidize the surface of the strip. Therefore, by cooling in a controlled atmosphere perfectly bright annealed steel strip is being produced. The heating time from room temperature to annealing temperature of 1400 F is approximately three seconds for 0.010 in. thick strip. This makes it practical to consider continuous annealing installations for steel strip at 600 and

Figure 9 — On the left is shown the metallurgical structure of SAE 4340 steel bar, 4½ in. square before heating, and on the right is shown the same bar after radiant gas heating.





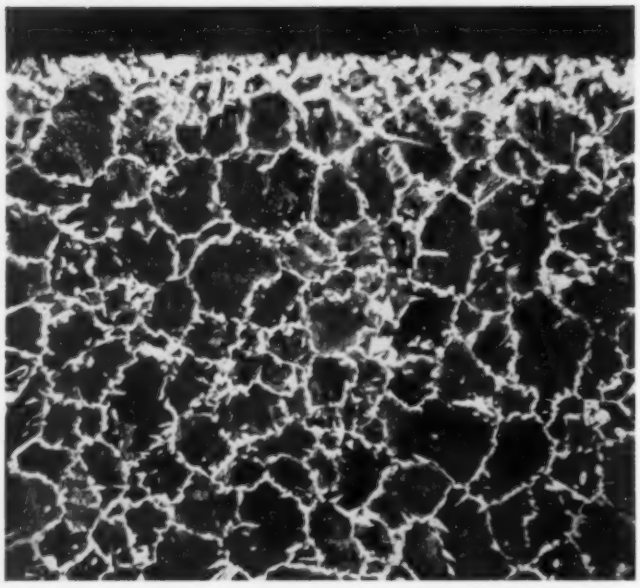


Figure 10 — The photomicrograph shows the surface condition of SAE 1040 steel bar, 1½ in., turned and ground to eliminate scale or decarb from previous operations. The bar is shown after radiant gas heating to 2250 F.

even 1200 fpm with substantial advantages in operating cost, enormous reduction of material in process, flexibility of operation and uniformity of end-product. At such speeds, the same tonnage now requiring a 100-hour cycle in hood type furnaces can be produced in three to five hours.

These illustrations of installations should suffice to show the variety of applications of high-speed heating in the steel industry, and to indicate some of the non-conventional and unusual results of this operating technique.

Summarizing briefly, we have seen:

1. The rapid annealing of stainless steel.
2. High-speed heating in combination with rapid quench that can produce a carbon steel product with physical properties equal to those of an alloy steel.
3. Under rapid heating conditions stainless steel reaches hot working temperatures faster than carbon steel.
4. Sensitive steels seem to be sensitive only to non-uniform heating and non-uniform cooling.
5. New control methods have been devised and still more will have to be developed, particularly with reference to emissivity of steel and temperature measurement of fast moving objects.
6. Bright steel can be obtained in a direct gas-fired continuous annealing process, which keeps the heating time and, therefore, contact with the products of combustion down to seconds.

We have seen other benefits, such as scale reduction, almost the complete elimination of decarburization, and reduction in grain growth. However, new effects are becoming apparent. For instance: if we examine the continuous strip annealing process we find some very interesting annealing results.

Figure 15 illustrates three so-called identical steels; that is, steels of similar composition and intended for the same purposes. The metallurgical structure is shown in photomicrographs on top. After passing through the high-speed annealing cycle under identical conditions the metallurgical structures of the same strips are shown below. It is evident that the structures are dif-

Figure 11 — On the left is a sample of SAE 52100 coarse grain steel which was heated by high speed radiant gas heat to 2100 F at a rate of two minutes per thickness-in. Sample was quenched after removal from furnace to arrest the grain structure. The right hand sample is the same material heated according to conventional practice.

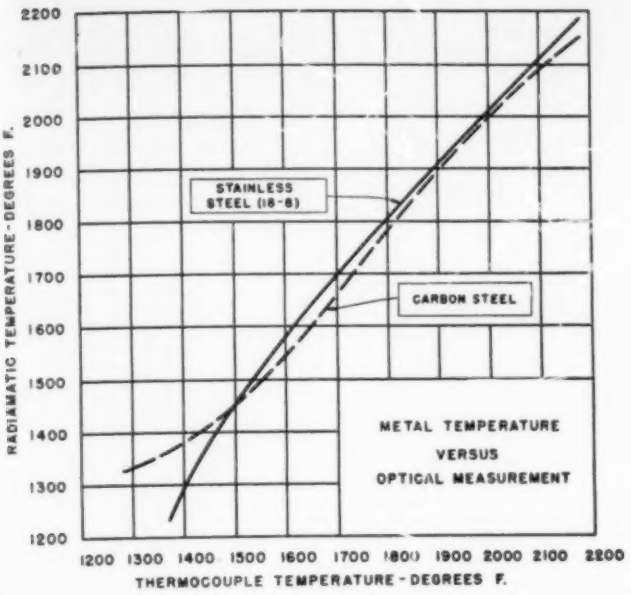


Figure 12 — The curves give a comparison of temperature readings from an optical pyrometer and from a thermocouple imbedded in the metal and recording on a millivoltmeter.

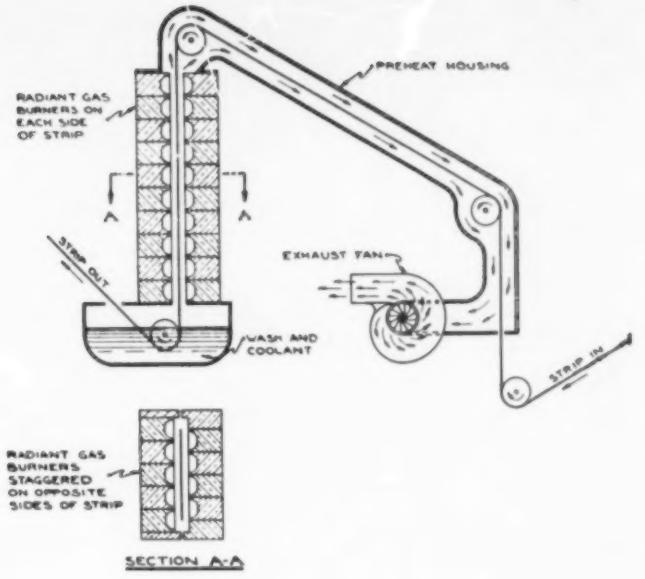


Figure 13 — Radiant gas burners have also been found very effective and efficient in reflowing electrolytic tin plate.

ferent and so is the hardness. Furthermore, if we compare these photomicrographs with similar photomicrographs of batch-annealed or long-cycle annealed steel, we find that the grains of our product are smaller (as might be expected) and that the steel tests somewhat harder (as might also be expected). However, it was unexpected to find different hardnesses obtained from so-called identical steels after identical heat treatment. Contrary to expectation also, these harder steels have better drawing characteristics than the softer batch annealed steels from the same coils.

Obviously therefore we have to devise a different classification for steels, not just hardness, grain size, carbides or pearlite, because these classifications do not seem to cover all the differences in physical behavior and physical characteristics.

In our attempt to obtain a clue for this difference, data was obtained by the electronic microscope, and Figure 16 illustrates two such photographs. There seems to be no striking difference between the two samples. The difference becomes even less in Figure 17 of the same samples when made somewhat larger, and yet sample No. 1 shows a continuously annealed steel having a Vickers hardness of 58, and sample No. 5 is the same steel unannealed with a hardness of 147.

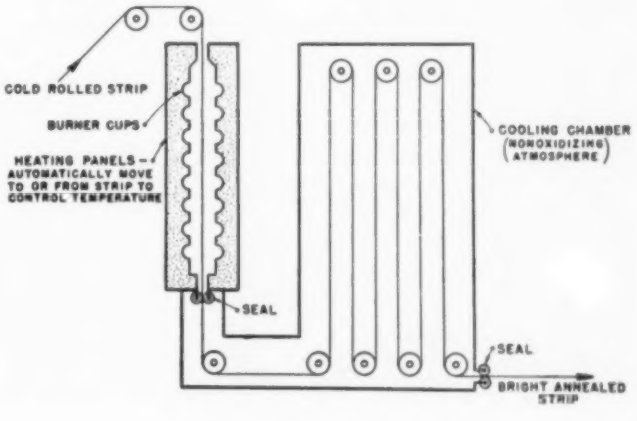
Practical experiences and resulting interpretations of effects, and present book knowledge, are obviously insufficient to explain fully or even understand all the behavior and effects of heat upon metals. We need to know more to plan deliberately and construct for production methods as well as for the products. Consequently, considerable research will have to be undertaken in an effort to secure this essential information —to provide better understanding of the working forces within metals.

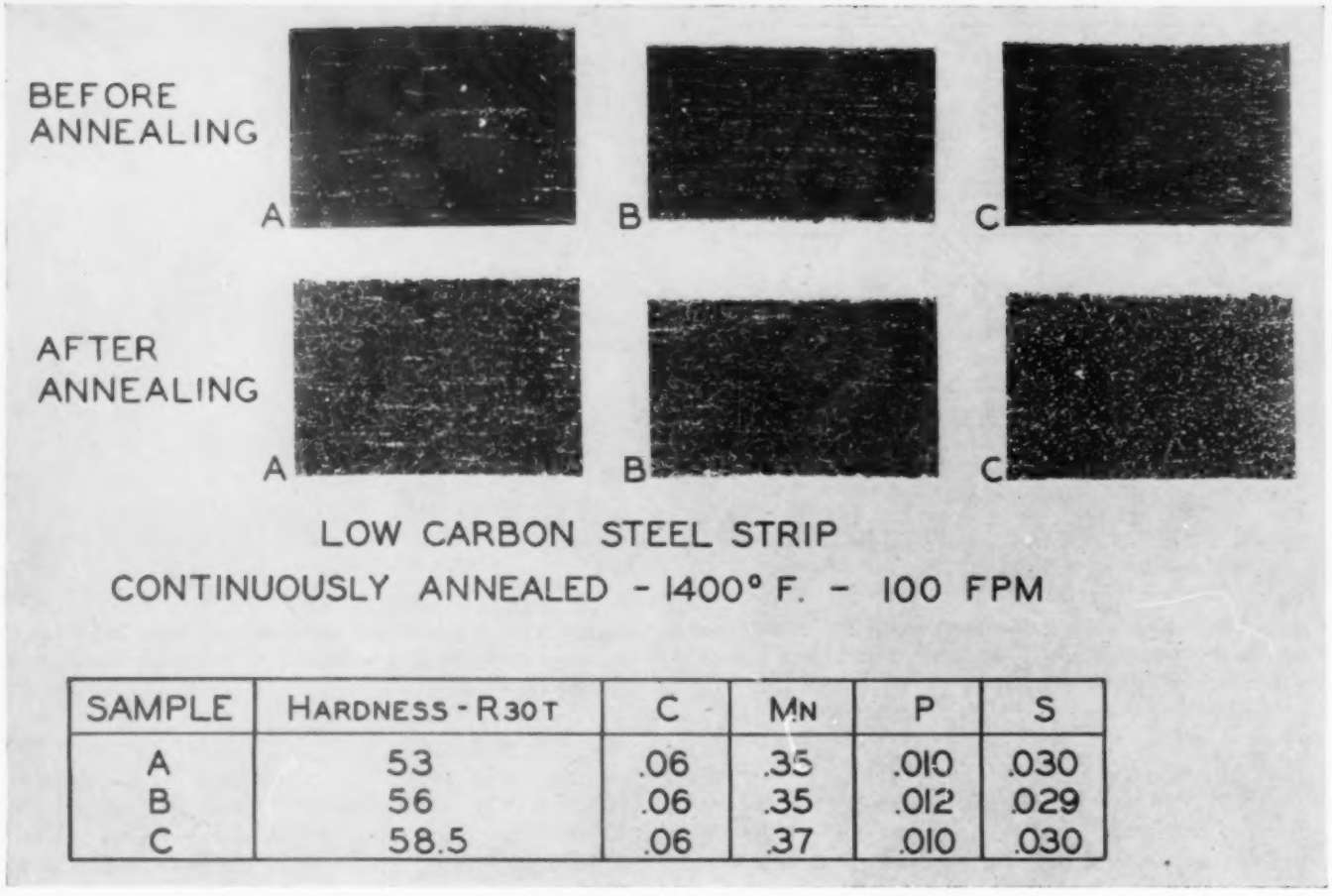
A very brief report by one of our foremost industrial laboratories deserves scrutiny because it might furnish a clue for specific research, as well as for some of our questions. It is reported that atoms within a block of silver at 500 C move 0.10 in. per week between grains. However, through grains they move only one inch in 10,000 years. Such speeds seem to be without relation to 5000 fpm rolling speeds, and to three seconds heating time. However, the findings of radioactive isotope, or tracer investigations should be analyzed.

First, it might be concluded from the difference in movement of atoms that there is a difference in resistance between grain and grain boundaries, or say a difference in viscosity. This difference is in the order of hydrogen to a stone wall, or in figures, 1 to 52,000. In other words, atoms move 52,000 times as fast between grains as through grains. We might therefore say that the grains are floating in a "gas" which we call grain boundaries. That brings to mind the adhesion between Johanson gages and the totally different effect resulting from a microscopic increase in film thickness.

If we carry this picture further into our everyday

Figure 14 — Diagram of continuous high speed strip annealing process that is based upon gas fired radiant panels prior to electroplating. The heating time from room temperature to 1400 F is about 3 seconds for 0.10 in. strip and production rates of 600 to 1200 fpm are practical.



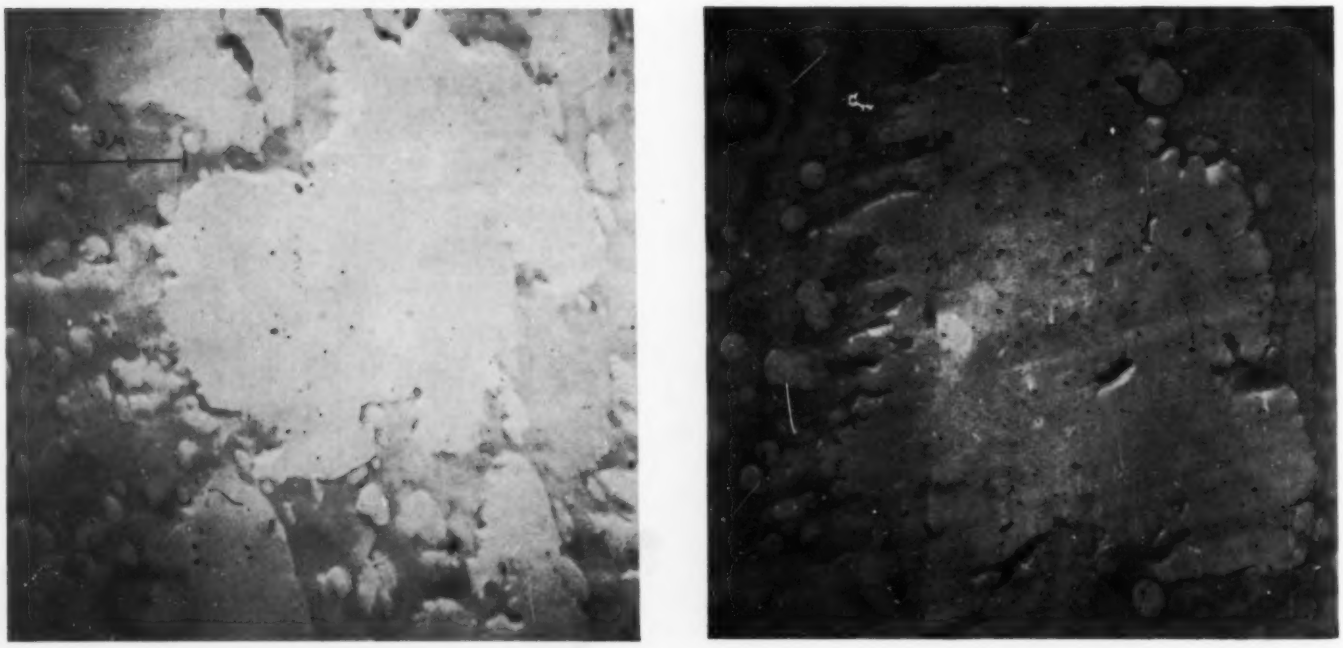


SAMPLE	HARDNESS - R30T	C	MN	P	S
A	53	.06	.35	.010	.030
B	56	.06	.35	.012	.029
C	58.5	.06	.37	.010	.030

Figure 15 — Identical type steels, heat treated in the same manner, may show different structure and properties after identical heat treatment.

concept, and dimension an atom as 0.00000001 in., it can be calculated that, in the boundaries, the atom moves 60,000 times its own diameter per hour, while in the grains it moves only slightly more than its own diameter per hour. If this atom projectile is enlarged to conventional dimensions of "feet," the result is a com-

Figure 16 — Steel samples under the electron microscope are illustrated here. The one on the left was continuously annealed and the one on the right was unannealed. Magnification is about 12500 X.



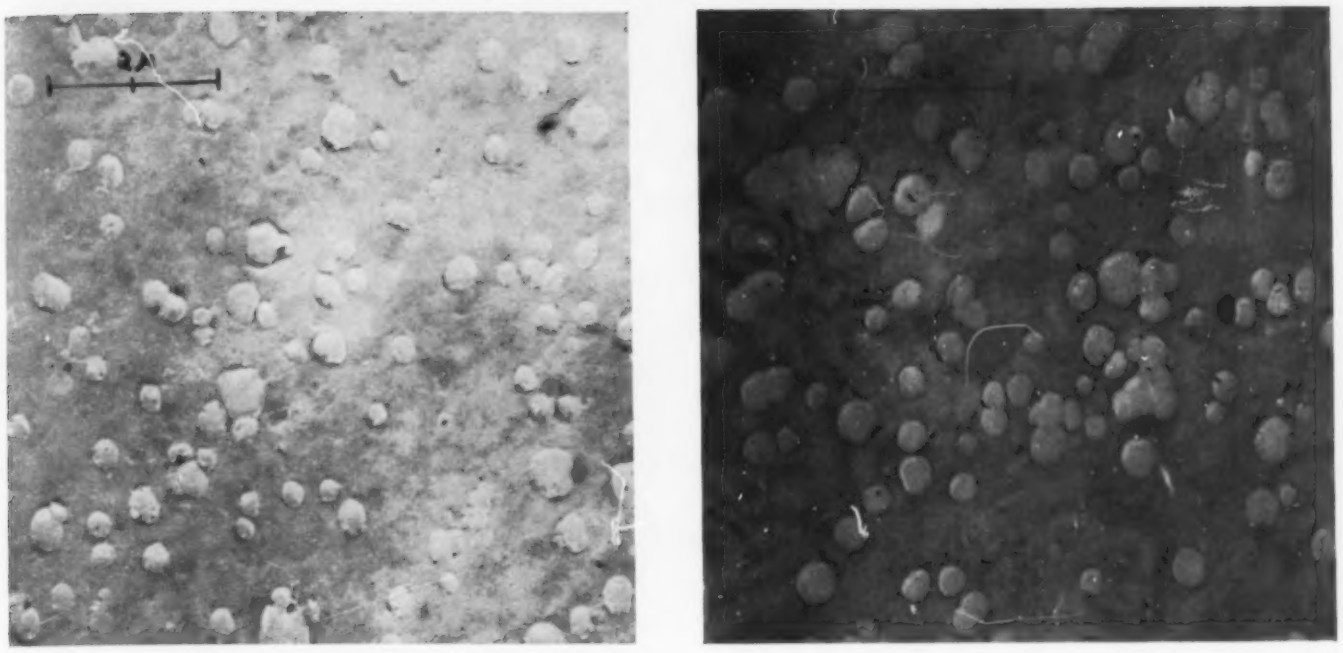


Figure 17 — The sample on the left was continuously annealed and the one on the right was unannealed, and are the same samples as in Figure 16. The photographs were made with the electron microscope and magnification is 18000 X.

parison of a one foot long projectile or one foot diameter ball moving 60,000 fphr or 1000 fpm in the gas boundaries, and only 1.15 fphr in the grains.

What happens when a moving object is decelerated 60,000 to 1 is known. No one has to stretch his imagination to picture the projectile as a fifteen-foot automobile traveling 60,000 times its length or 170 miles per hour coming up against a "viscosity" or resistance allowing it to travel only 15 fphr.

But what happens in metals? Are the atoms shattered or the grains battered? What speeds are present at 2200 F, and then what kind of acceleration can be surmised at different heating rates? In other words, can the shock of fast heating accelerate the atom movement and, if so, with what effect? Where does the grain growth fit into this movement-and-viscosity picture? What relation exists between composition of steels, alloying, atom movement, and strength?

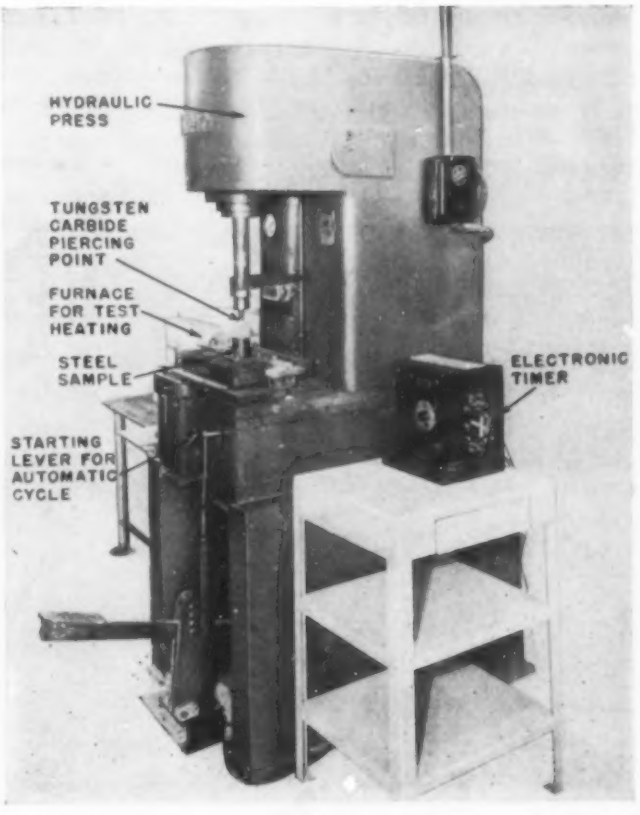
Whatever answers might be forthcoming eventually, one fact can be predicted safely—they will influence metallurgical design of metals as well as equipment and parts; they will govern and determine heat processing and enforce a revision in heating techniques which is already indicated, but just barely recognized and practiced.

It is already established beyond question that each steel, almost each heat of steel, has its own best hot working temperature for rolling or piercing. Yet how many production installations exist that can and will permit precise and practical accommodations of these precise temperature ranges? It is known that billets or slabs or ingots soaking during a mill shutdown are harder to work, but what is the degree of difference?

To obtain some indication of the influence of heating time on workability and evaluation of steels, more positive than just the "feel" of the mill operator, a series of tests were undertaken in a setup shown on Figure 18.

A hydraulic press, equipped with a 7/8 in. diameter tungsten carbide penetrator and set for a load equivalent to 2000 psi was used. By the use of an electronic timer the full load was applied to each specimen for exactly two seconds, and close to a hundred tests were conducted with different steels. The specimens were cut 2⅛ in. diameter x 2½ in. long, hot rolled SAE 1040 and SAE 52100. Naturally care was taken to eliminate

Figure 18 — This test setup was used for investigating the influence of heating time on steel plasticity.



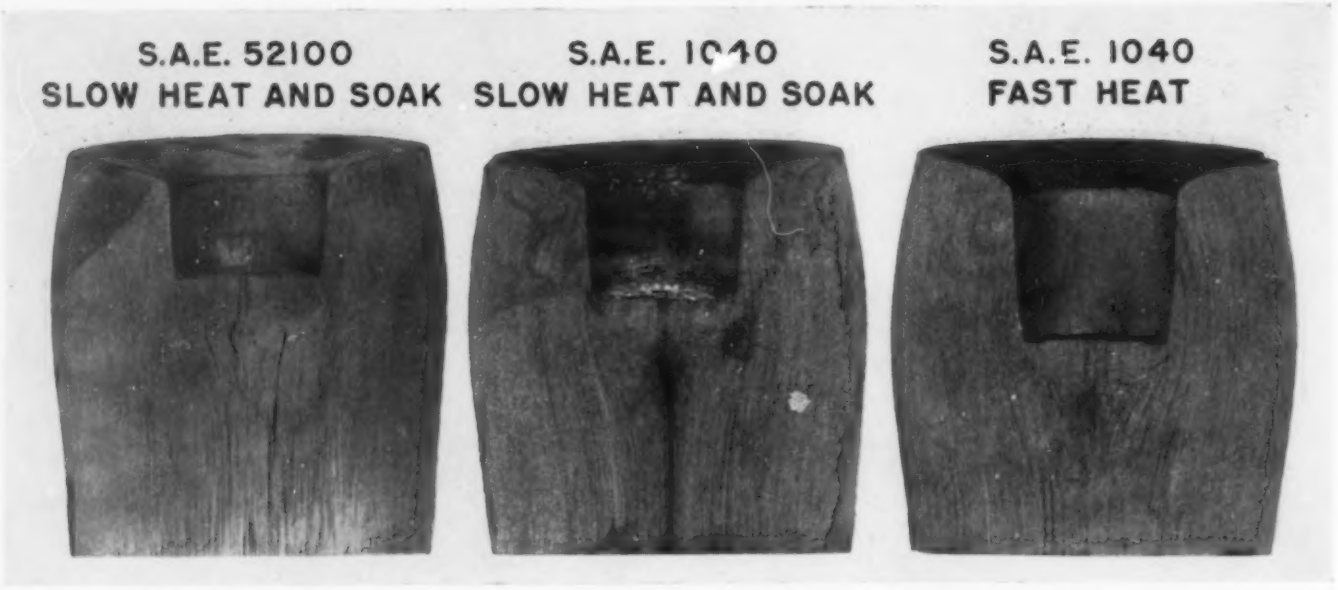


Figure 19 — The section shows the effect of heating time and composition on penetration of steel slugs heated to 2100 F.

errors or outside influences. For example, on all samples the top of the specimen was covered during the heating cycle to prevent scale formation on the surface, to which the penetration was applied. The heating furnace was built immediately adjacent to the press and optical as well as thermocouple temperature checks were made. Slow heating cycles were kept at ten minutes heat-up and thirty minutes soak; fast cycles were between four minutes twenty seconds to six minutes total time.

Figure 19 shows average results of numerous tests when employing reducing atmosphere during the heating cycles. It is apparent that the fast heated specimen permitted a twenty-three per cent deeper penetration than the slow heated slug of 1040 steel. The effect of the alloying element chromium in SAE 52100 is also shown. The penetration is twenty-eight per cent less than in 1040 steel, but the relationship between fast and slow heating remains the same, as can be seen on Figure 20.

These, briefly, are the indicated effects of heating times, effects sufficiently striking to justify serious considerations and more extensive investigations in laboratory setups as well as translation into actual production, such as forging, rolling, piercing.

Naturally this investigation raises the question of the causes. Why this difference in plasticity? It is beyond the scope of this paper to undertake a necessarily lengthy discussion and explanation, but very briefly at least one of the contributing factors can be shown.

Figure 21 shows the difference in intergranular oxide formation between slow and fast heated specimens. It is indicated by the appearance of large grayish grains or facets which seem to increase the internal friction. Special tests and observations seem to confirm this contention, but that subject will be covered in future presentations.

This paper will be closed with the prediction that major changes in mill practice and results are indicated, with an upgrading of heating and techniques. In the future, and that is right now, it is no longer a question of heating X tons of metal to a temperature or, worse yet, installing heating equipment of X cubic feet, or X gallons firing capacity, or rating a furnace by its hearth

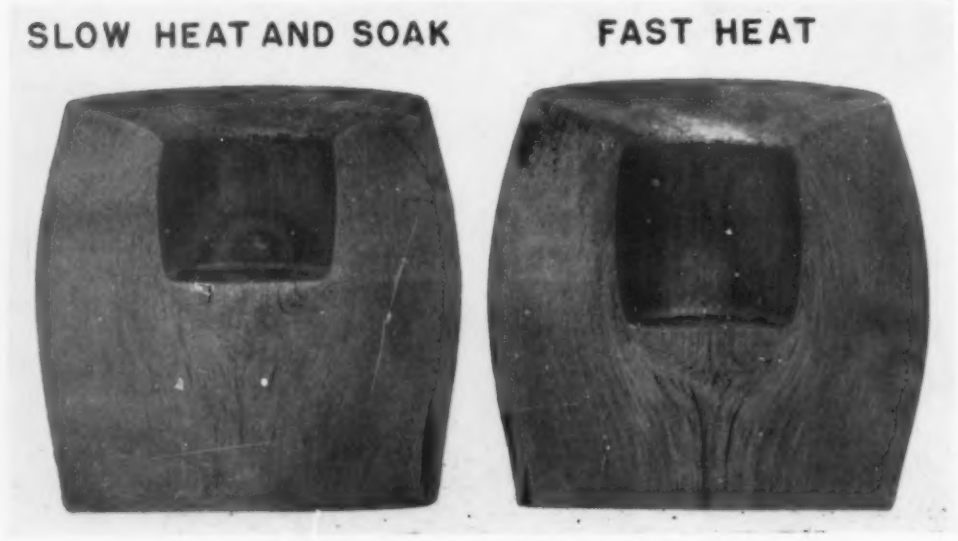


Figure 20 — Effect of heating time on penetration of SAE 52100 steel slugs heated to 2200 F.

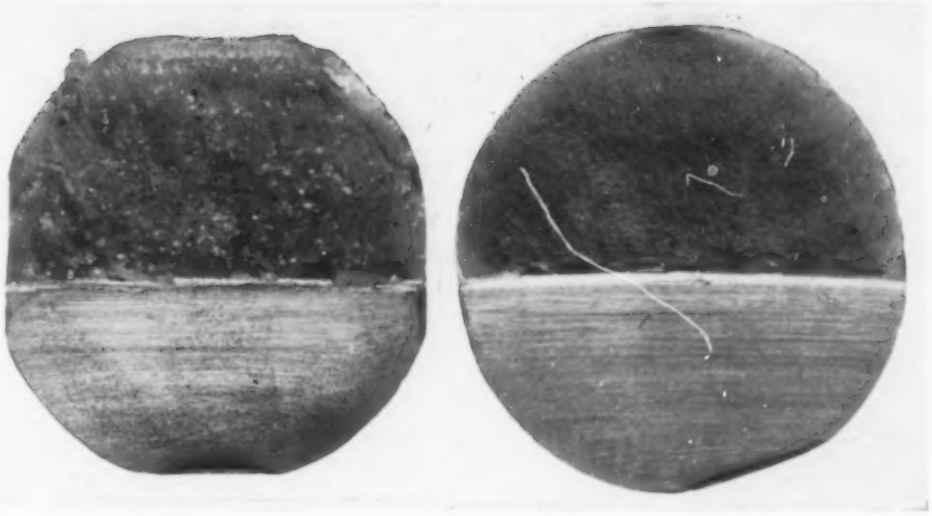


Figure 21 — Illustrated are samples of SAE 4340 1⅝ in. diameter bars heated to 2350 F in reducing atmospheres. The sample on the left was heated for 8 minutes plus a thirty minute soaking period. The sample on the right had a total heating time of 4½ minutes.

area. Mills, hot forming plants, will require that heating be coordinated precisely with end-product quality. Mills will have to practice and take full advantage of heat processing rather than operate with mere "heating."

DISCUSSION

PRESENTED BY

A. F. KRITSCHER, Development Engineer, National Tube Co., Pittsburgh, Pa.

A. F. Kritscher: Mr. Hess has certainly exposed several interesting facts and applications of high-speed heating, enough to invoke considerable thought as to the reliability of data which we now have accepted as gospel throughout the steel industry, especially on heating rates.

However, we must remember that existing data as applied to heating to forging temperature usually considers an object as heated from one side. It is known that production rates are increased by underfiring in certain types of furnaces. This means heating from two sides. If a billet or bar is heated from four sides, I believe we could expect to heat faster than if applying heat from two sides. Evidently, the ingenuity of heat application and the manner in which the steel is exposed to heat has a tremendous effect on heating rates. It thus becomes apparent that high-speed heating is closely correlated to the manner in which the recipient metal is exposed to the heat source.

To further analyze high-speed heating, one must consider the heat source and the relation of its location to the steel to be heated. If high temperature surfaces can be placed very closely to the absorbing metal and a very wide temperature difference can be maintained between the radiating heat source and the steel, the fundamental rules of heat transfer account for the great rate of heat input.

High-speed heating thus evolves itself into the most complete exposure of the surfaces to be heated by a heat source of a temperature as high as practical and as close to the surface of the material to be heated as applicable.

In commenting, it is the development of practical means for maintaining very high temperature differentials in applying heat evenly incorporated into ingenious furnace design, which has been the important contribution to better heating of steel, rather than the resulting heating speeds which do not appear phenomenal if the ultimate in steel surface exposure and temperature differential is obtained by sound application.

Mr. Hess and his organization certainly have demonstrated that high-speed heating can be practically applied to most any heating job.

In defense of the existing steel mill heating furnaces, I feel that it can be said that although the heating rates are slow, they are not doing a poor heating job since one must consider that in most cases large masses of metal are being heated from one side only.

Mr. Hess also points out the desirability of having temperature measuring instruments which are beyond the influence of scale surface conditions and emissivity under production operations. The influence of heating can usually be distinguished in the processed steel and closer control of true heating temperatures are necessary to improve the quality of the end product.

During our investigations of high-speed heating, we have never been able to fully understand all of the effects of fast heating. We do know that steel can be pierced into tubing with less power if the steel is not soaked at forging temperature and, also, with quick heating the forging temperature can be 175 F lower and not require any more piercing power than heated and soaked steel. Evidently high speed heating causes a change to the values of the resistance to compression curves we presently use in rolling calculations.

With the advent of high-speed heating, engineering thinking must necessarily change, especially as to handling of hot and cold steel and arrangement of production facilities to benefit from the advantages this type of heating does offer.

A. S. Glossbrenner

PRESIDENT, 1950

ASSOCIATION OF IRON AND STEEL ENGINEERS

ALBERT S. GLOSSBRENNER attended the University of Wisconsin and later entered the employ of the old Illinois Steel Co., one of the predecessors of Carnegie-Illinois Steel Corp., at the Gary, Ind. tin plate plant. He then transferred to the same company's South Works at Chicago as assistant foreman. Five years later he joined Youngstown Sheet and Tube Co. at Youngstown, Ohio, as assistant superintendent of the hot strip mill becoming superintendent about three years later. He was appointed superintendent of the Brier Hill plant in September, 1942, and in 1943 was named general superintendent of the Youngstown district of Youngstown Sheet and Tube Co. In December 1946, Mr. Glossbrenner was named assistant vice president of operations.

The President's Message

During this era of accelerated rates of change, each new year offers a challenge to all industry, and the year 1950 will, without question, be an unusually challenging one, particularly to all of us having anything to do with the iron and steel industry. It is the general forecast that next year will see the establishment of an extended period of healthy competition, under conditions, it is to be hoped, that will not prove too restrictive.

We will find it necessary, as individuals and in cooperation with others, to work harder and to do more thinking and studying than most of us ever have done before — all toward the more efficient direction of our energies. With that end in mind, it is my sincere and most earnest desire that our Association be of help to each of you, through the sponsoring and carrying out of broad programs which will both disseminate and give direction to the knowledge of the day most effectively.

Your participation in these programs will be doubly beneficial, as it is through your efforts that the Association of Iron and Steel Engineers will continue to grow and occupy the important position in the industry it has held for so many years.

A. S. Glossbrenner

President, AISE

JOHN F. BLACK

First Vice President

I. N. TULL

Second Vice President

JOHN L. YOUNG

Treasurer

Newly Elected Officers and Directors

JOHN F. BLACK received his elementary schooling in the Enid, Okla., city schools and attended the United States Naval Academy, class of 1926. He started in the steel business as pipefitter helper at Bethlehem Steel Co.'s Sparrows Point plant, progressing to steel shipper, labor foreman, gashouse foreman, general foreman of gas producers, combustion engineer, and general foreman of pipe mills. In 1941 he transferred to Atlas Steels, Limited, Welland, Ontario, as fuel engineer and in 1943 was made assistant works manager. In January 1947, Mr. Black was appointed general superintendent, Buffalo plant, Wickwire Spencer Steel division of the Colorado Fuel and Iron Corp. In December 1949, Mr. Black went to work for the Youngstown Sheet and Tube Co. as assistant general superintendent, Indiana Harbor.

I. N. TULL was born in Anniston, Ala., reared in N. C., and graduated from North Carolina State College in electrical engineering in 1910. After a brief period of telephone work, he entered General Electric Co.'s test course at Schenectady. He was transferred to their Cleveland office's engineering department in 1912, remaining there until 1915, when he was employed by Corrigan, McKinney and Co. as electrical engineer. The next 12 years were spent in engineering and construction work as that company built blast furnaces and a steel plant at Cleveland, Ohio and proceeded with extensive electrification of their iron mines and the opening of coal mines. In 1927, general supervision of electrical maintenance and operations was added to the construction duties. After the merger with Republic Steel Corp. in 1935, Mr. Tull became electrical superintendent of the Cleveland district for Republic.

JOHN L. YOUNG is a native of Evansville, Ind. and graduated from the University of Indiana. Mr. Young began his career with Timken Roller Bearing Co. in Canton, Ohio, where he held various positions in the alloy tube and steel departments; he later transferred to the metallurgical department. In 1930, Mr. Young went to Pittsburgh for Timken as a development engineer, and later returned to Canton and became assistant general manager of Timken's Industrial division. Mr. Young joined United Engineering and Foundry Co., Pittsburgh, Pa., in 1936. In 1941, he was loaned as project manager to design and construct the Defense Plant Corp.'s aluminum rolling mills at Trentwood, Wash. He was vice president in charge of industrial research and development for United Engineering and Foundry Co., before assuming his present position as vice president in charge of engineering of United States Steel Corp.'s National Tube Co. in 1945.

E. L. ANDERSON has been associated with the iron and steel industry for over 30 years, having started in the electrical department of the Bethlehem Steel Co. at Sparrows Point, Md., in 1917. He was transferred to the Johnstown plant of Bethlehem in 1937, and was appointed superintendent of the electrical department of that plant in 1940.

J. H. VOHR was graduated from Cornell University in mechanical and electrical engineering in 1916 and became associated with the New York State Railways as an electrical engineer. After serving in World War I, he joined the American Sheet and Tin Plate Co. at Farrell, Pa., and later was transferred as assistant superintendent of strip mills to the company's plant at Gary. After leaving the company in 1931, he was engaged with the installation and operation of the wide strip mills of the Inland Steel Co. and Youngstown Sheet and Tube Co. In 1936 he joined the Granite City Steel Co., Granite City, Ill. as superintendent of the hot and cold strip mills and was promoted in 1937 to general superintendent of plants. In 1942 he transferred to the Carnegie-Illinois Steel Corp., being stationed at the general offices in Pittsburgh until his appointment in 1943 as assistant general superintendent of South Works of Chicago, Ill. In 1949, he was promoted to the general superintendency of Gary, Ind. steel works.

RYLAND J. BEESWY started working for the Inland Steel Co. as an open hearth motor inspector in 1916. He served in the Navy in World War I. In January 1942 he was promoted to assistant superintendent of the Electric and Power Departments. He assumed his present position of assistant superintendent of Electric, Power and Steam Departments in January, 1947.

E. L. ANDERSON

Secretary

J. H. VOHR

Director-at-Large

RYLAND J. BEESWY

Director

HENRY E. DAVIS

Director

F. S. ECKHARDT

Director

CHARLES P. HAMMOND

Director

ASSOCIATION OF IRON AND STEEL ENGINEERS 1950

HENRY E. DAVIS, superintendent of maintenance for Republic Steel Corp. at Buffalo, N. Y., was born in Kansas and attended Chicago public schools. He began work with Illinois Steel Co. at South Chicago in 1900. Following an apprentice course there, he worked at various times for Buffington Cement Co., Inland Steel Co., Wisconsin Steel Co. and Colorado Fuel and Iron Co. In 1912 he joined Interstate Iron and Steel Co. as chief electrician, and remained through that company's mergers with Central Alloy Steel Corp. and Republic Steel Corp. In 1935 he was transferred to Republic's Buffalo district. He is a life member of the AISE.

F. S. ECKHARDT is a native of Hamburg, N. Y., educated in Hamburg Public Schools and took extension work at the University of Buffalo. He has always worked for Bethlehem Steel Co. entering their employ in 1922 at the Lackawanna Plant as a tracer in the Engineering Department. Advancing through the drawing room, he was appointed assistant chief engineer in 1937 and chief engineer in 1940.

CHARLES P. HAMMOND was born in Chester County, Pa. where he received his elementary schooling. Further education was obtained through night school at Drexel Institute and Temple University, and other work at Carnegie Institute of Technology, University of Pittsburgh and Columbia University. He joined the Midvale Steel Co. organization in 1914. Later he was a roller for Hess Steel Co. (now Rustless Iron), and United Alloy, Canton, Ohio (now Republic Steel). In 1925, he joined the Crucible Steel Co. organization as roller and was promoted to superintendent of mills, Park Works, Pittsburgh. In 1928, he joined Universal Cyclops, later rejoining the Crucible Steel Co., at Atha Works, in Harrison, N. J. He came to Atlas Steels Limited, Welland, Ontario in 1933 and for 15 years was superintendent of mills. Late in 1948, Mr. Hammond was appointed superintendent of mills of the Rotary Electric Steel Co., Detroit, Mich.

JAMES N. IMEL was born at Cambridge Springs, Pa., in the year 1907. He received his elementary and high school education in Cleveland, Ohio and graduated from Bethany College, Bethany, W. Va., in June, 1930. He started to work with the Jones & Laughlin Steel Corp. shortly after his graduation as a student trainee. After holding various jobs in the Rolling Mills Department, he was advanced to the position of general foreman, D.S. Mills in 1937. In April, 1946, he was promoted to the position of assistant superintendent of rolling mills and, on August 1, 1947, was appointed superintendent of rolling mills, Pittsburgh works, which position he now holds.

K. L. JOHANNSEN was born in Ricketts, Iowa where he received his elementary schooling. He graduated from Iowa State College, Ames, Iowa with a Bachelor of Science Degree in Electrical Engineering in June 1933. He was employed as a wireman in the Electrical Construction Department of the Gary Sheet and Tin Mills, Carnegie-Illinois Steel Corp. in 1936. In December, 1937 he was transferred to the Irvin Works of the Carnegie-Illinois Steel Corp. as an electrical inspector cold reduction mills during the construction of the plant. From March 1938 to May 1941 he worked in the Cold Reduction Department with his last position being general maintenance foreman. From 1941 to 1945 he was general maintenance foreman of the 80 in. Hot Strip Mill. In December 1945 he was transferred to Duquesne Works where he was made assistant superintendent of maintenance, and on January 1, 1948 he became superintendent, assigned and operating maintenance, which position he now holds.

EMIL KERN was graduated from the University of Stuttgart, Germany, in 1926, and began his career as a machinist and designer with Mesta Machine Co. in 1930. He became associated with Reynolds Metals Co. as chief mechanical engineer in 1945 and joined the Allegheny Ludlum Steel Corp., Pittsburgh, Pa. as chief engineer the following year. In May 1949, he was elected a vice president of the Allegheny Ludlum Steel Corp.

JAMES N. IMEL

Director

K. L. JOHANNSEN

Director

EMIL KERN

Director

ROBERT A. KRAUS

Director

H. F. LESSO

Director

GEORGE STEWART MONKS

Director

ROBERT A. KRAUS, a native of Chicago, obtained bachelor and master degrees in mechanical engineering at the Illinois Institute of Technology. In 1939 he entered the steel industry joining the Republic Steel Corp., in Chicago, as a junior mechanical engineer and later as an industrial engineer. In 1943 he was appointed lubrication engineer and in this capacity assisted in the construction of the Republic Chicago Defense Plant. In 1947 he was named to the position of general mechanical foreman for the Chicago properties.

H. F. LESSO, open hearth control and materials metallurgist, Great Lakes Steel Corp., was born in Hanover, Ontario, Canada. He received technical education in Chemical Engineering, majoring in metallurgy at the College of the City of Detroit from 1928 to 1931. Mr. Lesso entered the employ of the Great Lakes Steel Corp. in 1931. After serving three years in the rolling and finishing departments, he was transferred to the technical division, remaining in the latter department for nine years. In 1943, he was transferred to the open hearth department to head the materials control division.

GEORGE STEWART MONKS was born in Grove City, Pa. He attended high school in Pueblo, Colo. and Allegheny, Pa. His experience has been in the drawing rooms of various steel concerns starting during summer vacations with Colorado Fuel & Iron Co. in 1902–3. He began his service with Jones & Laughlin in 1914 as a draftsman, later working as a machine designer and then as chief draftsman of the Pittsburgh Works. He was appointed resident chief engineer of the Otis Works at Cleveland, Ohio in 1942 when The Otis Steel Co. merged with Jones & Laughlin Steel Corp. He retired effective January 1, 1950.

GEORGE W. NIELSEN was born in Chicago, Ill. and moved to Alabama at an early age where he attended school. He served as an apprentice machinist for the Fred W. Wolfe Co. of Chicago, and after service in World War I, has been continuously in the employ of Tennessee Coal, Iron, and Railroad Co. Starting as a machinist, he was made shop foreman, general foreman, assistant master mechanic and at present is mills master mechanic, Fairfield Steel Works.

WILLIAM A. SMILEY was born in Dayton, Ohio, and reared in Pennsylvania, where he was first employed as a teacher in the public schools. He later served some years as a cost accountant specializing in business reorganization. A side line as consulting radio engineer was abandoned with the advent of the radio trusts in 1923. The prospect of developing electronic applications in industry induced him to enter steel mill work in 1924, as an electrician with the Bethlehem Steel Co. After some years of research and development work he became electrical engineer at Steelton which position he now holds.

H. T. WATTS was born at Louisville, Ky., and attended the public schools in that city, receiving his bachelor's and master's degree in mechanical engineering at the University of Kentucky in Lexington. Mr. Watts was first employed at the Youngstown Sheet and Tube Co. in Youngstown, Ohio, in the steam engineering department. He later became assistant steam engineer for that company. Mr. Watts transferred to the Otis Steel Co. in Cleveland, holding the position of steam engineer for that company. He joined the forces of the Surface Combustion Corp., and was stationed at Pittsburgh in sales work and development. He was later appointed superintendent of power for the Gulf States Steel Co. at Gadsden, Ala., and later became combustion engineer for the same concern. This company was absorbed by the Republic Steel Corp. in 1937, and Mr. Watts holds the same connection with the Gulf States Steel Division of Republic.

GEORGE W. NIELSEN

Director

WILLIAM A. SMILEY

Director

H. T. WATTS

Director

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1949 C. H. WILLIAMS, *Chief Engineer*, Carnegie-Illinois Steel Corp., Pittsburgh, Pa.

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E. C. HITE, *Maintenance Engineer*, Steel and Tube Division, Timken Roller Bearing Co., Canton, Ohio.
J. R. PRICE, *Maintenance Superintendent*, Youngstown Sheet and Tube Co., East Chicago, Ind.

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C. E. PRITCHARD, *Chief Lubrication Engineer*, Republic Steel Corp., Cleveland, Ohio.
N. I. WHITELEY, *Lubrication Engineer*, American Steel and Wire Co., Cleveland, Ohio.
W. L. DOUGLASS, *Lubrication Engineer*, Lukens Steel Co., Coatesville, Pa.

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JOB ANALYSIS AND EVALUATION *in Personnel Management*

By KENNETH A. DUNN
Supervisor, Salaried Personnel
Ford Motor Co.
Dearborn, Mich.

. . . . the job analysis and evaluation system described provides a sound basis for establishing salaries and evaluating the employees . . . .

▲ AS a preface to this discussion of job analysis and evaluation in personnel management, it is advisable to establish a definition of terms. First, what kind of "Job Analysis" is being discussed? The term is a general one and can be applied to any of three types of study: First, methods study, which deals with procedures; secondly, time study, which deals with time and motions for the establishment of standards; and third, job requirements study, which is intended to develop not only the requirements that are placed on the employee, but also to serve as a basis for the establishment of the relative value of jobs.

This discussion will concern itself only with the third application; that is, the use of job analysis as a means of determining job requirements and establishing relative worth of jobs. Job analysis in this sense deals only with the jobs and not with the individual and can be applied to all types of jobs whether they be production, clerical or supervisory. Each level requires a little different approach and this paper will deal only with so-called clerical, or non-production, non-supervisory positions.

Personnel management is but one phase of general management. Management as such involves the utilization and control of men, power, machines, and materials to attain a given objective. In the steel industry then, management involves the control of men, power, machines and materials for the production of iron and steel. Personnel management, in steel and all other industry, has for its purpose, not only the supply of manpower—one of the four requirements for the attainment of production—but also the control of such manpower and the securing of maximum productive efficiency. In order to attain this maximum productive efficiency, personnel management must concern itself with adequate payment to manpower. In general then, personnel management can be regarded as concerned with efficient control of manpower as other phases of management are concerned with the efficient control of material, power and machines.

We find that there are two distinct approaches to

Figure 1 — This form was made out by the employee to describe his or her duties.

Ford Motor Company

Employee Position Description — (Reserve this space)

Present Job Title: Typist D
Suggested Job Title: Typist
Division: Any Division — Department
Section — Unit
Immediate supervisor - Title and Name — Supervisor next in Charge - Title and Name

DESCRIPTION OF DUTIES AND RESPONSIBILITIES:

1. Work which is done daily. — Approximate hours per day on each duty.

a. Stencils cut from printed material and rough drafts; this includes straight typing, reports and charts. — 5

b. General typing from printed material and rough drafts; this includes straight typing; communitions, request for shipping orders, reports and charts. — 3

(Use additional sheets if necessary)

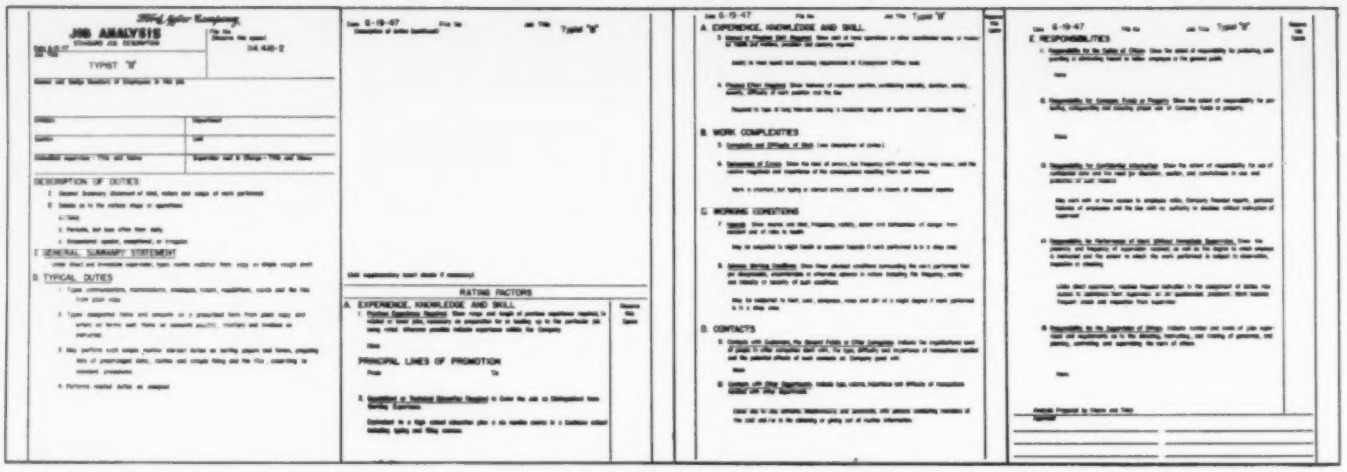


Figure 2 — This four page form is used by the job analyst to prepare a complete analysis on each job. The form shown is made out for a typical typist.

personnel relations: there is the personal aspect that deals with the employee as an individual and provides such things as medical benefits, insurance plans, vacations and the like. Then there is the impersonal phase that regards the employee objectively and in terms of job requirements, job duties and the value of those duties properly performed.

Industry has long recognized the personal aspects of manpower control, and vacations, medical and pension plans and the like are in general use. Strangely enough, however, although the prime reason for the presence of manpower is the performance of job duties, the great majority of companies have no definite program for the study of job requirements and duties nor for the administration of wages and salaries. A nation that has installed production systems, inspection systems and work simplification procedures to the extent that it out produces virtually the entire world, has done little to bring the same research to wage and salary administration. In organizations that pride themselves on precision workmanship, one often finds that workers performing the same tasks are paid at widely differing wage rates and that there are no logical reasons for the existing relationships among the rates for different occupations.

Job analysis has been defined as a method for the determining of facts about jobs, and job evaluation as a means of establishing the relative worth of those jobs. Job analysis and evaluation can and will provide the basis for the research and system that is so sorely needed in wage and salary administration. Thus, job analysis and evaluation is a necessary part of any well rounded personnel management or personnel relations program.

Although some form of job analysis and evaluation has been used since the first employer-employee relationship was established, it was generally of an informal nature. Ever since biblical times when one man was hired to work for another, the employer had some standard by which he paid the worker; further, each party had some mental picture of the requirements and duties of the job, albeit no written description was prepared. However, the methods used when industry was small have little bearing on industrial and economic conditions of today. An employer with a mere handful of employees and having a centralized or line type organization, had full knowledge of all jobs and because of economic conditions, was satisfied to pay a rate commensurate with the "going scale" and with the individual characteristics of the employee involved.

Today, no one man has complete knowledge of all of the jobs in a large organization and is therefore unable to accurately measure the fine economic conditions which have forced us to establish wage and salary patterns by which labor will be rewarded. Accurate analysis of job duties, and evaluation of them requires a knowledge and a consideration of all of the factors of each job. And there is no one man in any large organization whose personal experience is great enough to permit him to immediately picture all of the factors that go into each job, nor to permit him to place an equitable and related value on all jobs in his organization. Hence, it is job analysis and evaluation that provides the tool whereby all factors of each job can be appropriately considered and an equitable value determined.

Job analysis and evaluation as such are relatively new and strangely enough had an early beginning in the steel industry. In 1881, Frederick Taylor, a pioneer in the management field, while doing a job survey at Midvale Steel, prepared a sequential listing of the duties that a worker went through. This listing of duties in sequence was a deviation from the accepted time study methods used to study motion and fix standards and was in effect the first job analysis or job description as they are known today.

The first large scale application of job analysis and classification systems was made in the use of United States Government classifications during the First World War. The method used consisted of setting up theoretical job specifications or lists of job duties, setting a predetermined value upon them and forcing workers and systems into the jobs. This was soon abandoned in favor of the method of preparing descriptions of the jobs as they were actually being performed and then establishing a value.

During the years of World War II, job analysis and evaluation and formalized classification structures gathered impetus. This was particularly true because of the various salary and wage controls imposed by the government upon industry. As a result, many companies today find themselves in possession of wage and

salary structures and methods of administration which they are strengthening and perpetuating. Varied programs are today in operation in such companies as International Harvester, Atlantic Refining, General Foods, United States Steel, Westinghouse and many others.

In general there are four basic types of job analysis and evaluation plans and for clarification each type will be mentioned briefly. This paper will not attempt to go into all of the technical aspects of each plan nor attempt to recommend any one method as the best. Each has its own application and benefits and as with all other tools must be selected in light of the problem and the need.

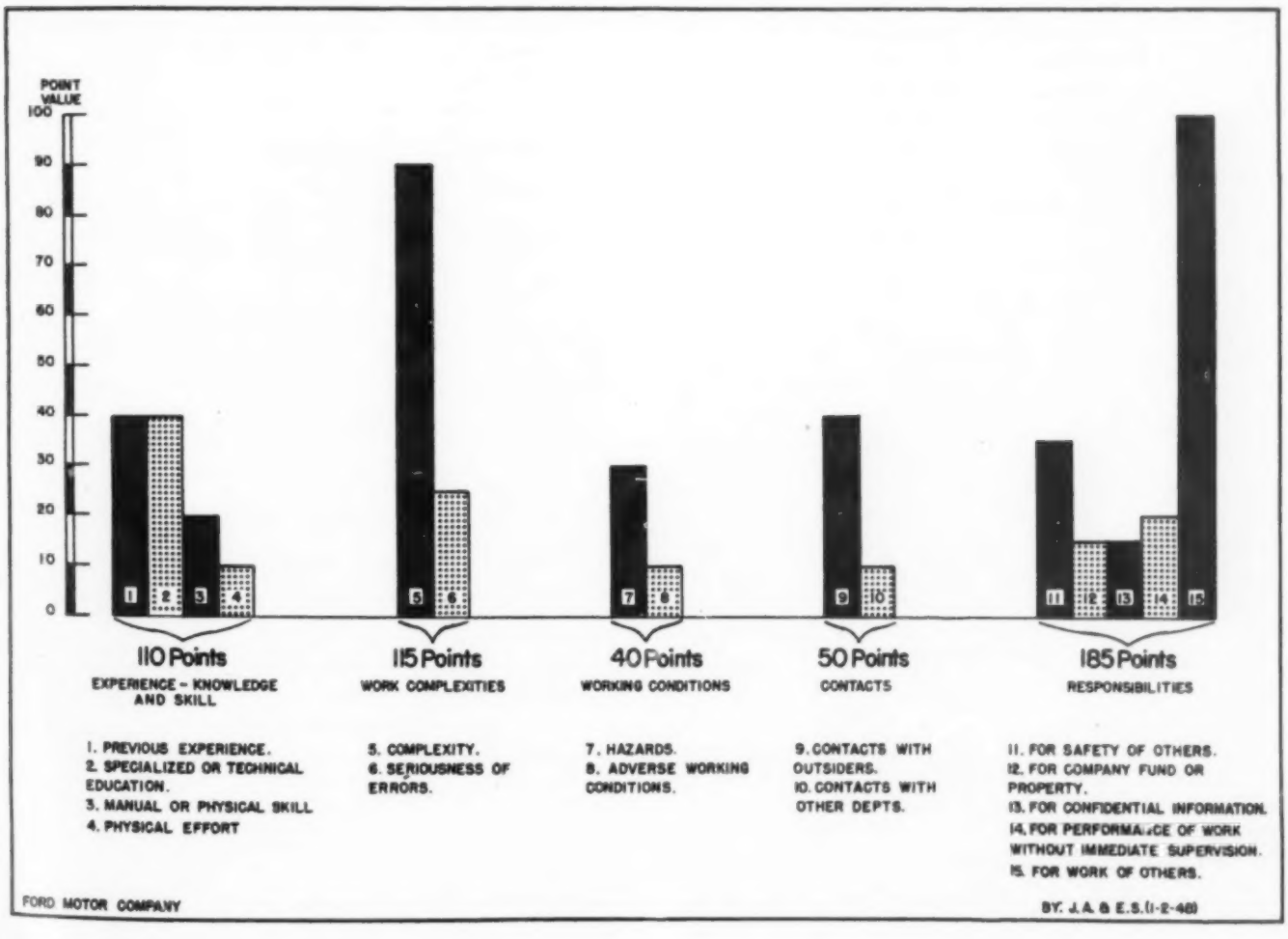
The most commonly known procedure is the ranking method. Here jobs are ranked from the most important to the least important, and generally each department head or supervisor ranks the jobs in his own area. The coordination or company wide ranking by a committee consists of placing the jobs into grades or classes which have been previously set up with appropriate values. This method is easy to use, particularly where relatively few jobs must be considered, but it is difficult to validate and its simplicity is no guarantee of accuracy. Again it is difficult to accurately rate or rank all jobs unless all are compared to the same set of standards. Further, a pure ranking provides no measure of the degree of difference in value that exists between any of the jobs and this makes for difficulty in equitable payment.

A second common method is the classification system. Here grades or levels of difficulty are set up in advance, jobs are analyzed as to duty requirements and are placed into the proper grade and paid for accordingly. A simple example is one which uses but three grades, unskilled, semi-skilled, and skilled. As each job is considered, it is compared to the definitions adopted for the three grades and is placed in the appropriate one. Again, each job is regarded in toto with no regard to individual factors and the result is often hard to validate or justify because of the non-specific nature of the grades.

A third method is a pure point rating procedure. Here each job is broken down into factors such as "required experience," "education," "mental and physical effort" and so on, and points awarded on the basis of the amount each factor is required. Factor definitions are used as standards and the final position of the job is determined by the point value of the combined factors. This method has been attacked as too scientific and inflexible and therefore difficult to understand by workers and the average supervisor.

Fourth, is the factor comparison method. Factors believed common to all jobs are selected, defined by appropriate statements and assigned point values. Each job is compared to each factor and then to all

Figure 3 — The valuation of a job is based on a set of 15 factors



other jobs on that same factor and a point value assigned. Here the standard used for rating is not only the technical scientific standard, but also the actual standards provided by other jobs in the organization. As in the point method, a point value is assigned each job and final relationship and value established.

With the establishment of government controls during the war, the Ford Motor Co. set up a job classification and salary range system which was based generally on "going rates" and accepted and existing job titles. Briefly, this structure, applied to some 20,000 salaried, non-union, non-production employees, was based on nine levels or grades of responsibility and included some 450 job titles. After the close of the war an examination of the structure revealed inadequacies which we felt could be corrected only through a formal job analysis and evaluation program.

The programs of other companies were studied and it was found that the large number of employees and jobs to be covered would require a program specifically designed for office type jobs. An outside consulting firm was retained and their basic plan was modified to fit our needs. Under the guidance of the consulting engineer, Ford personnel were trained as job analysts, an organization was set up and the plan was initiated in 1946.

The Ford program embraces three of the basic types of job analysis and evaluation procedures. Early jobs were rated on a point basis alone and as more and more jobs were covered, they were compared factor by factor with other jobs and final review and approval was accomplished by a system of ranking by members of supervision.

Job analysis and evaluation is a tool or a method and not an infallible panacea and it must be recognized that jobs are affected by the human elements; therefore, human experience and judgment must be used in addition to the scientific formula. No job analysis and evaluation system is perfect and its success can be determined only by actual use. Whether or not the system is "livable" can be proven only by submitting the results to the people who have to live and operate under it: the employee and the supervisor.

Engineers may ask why a tool should be used that is admittedly imperfect. In answer, in a large company there are as many job analysis and evaluation methods as there are employees—each person looks upon his own job and those about him in the light of his own experience. Each person, whether he be worker or supervisor, places his own value on each job. The problem of exacting a proper and equitable relationship between jobs, then, is met by insuring that each job is regarded in the same light, compared to the same set of standards and rated free of personal prejudices or opinions. The benefit of a job analysis and evaluation program stems not from its infallible accuracy, but from the consistency of rating or review which can be accomplished.

It has been mentioned that no program can be successful unless it is livable. Further, it must be understood and accepted by the people of the organization. Our research determined that 80 per cent of the job analysis and evaluation plans that failed lacked employee and supervisor participation and understanding. The Ford program seeks to avoid this failing by utilizing both the technical and practical approach and by providing for both employee and supervisor participation. Basic job information for the analysis is gathered with the help of the employee, the initial rating is done by a job evaluation technician and the final review and approval comes from supervision.

The program was introduced in each department through a meeting with the head of that department and all of his subordinate supervisors. The purposes and procedures of the program were discussed and all forms and methods to be used were examined and explained. Following this general meeting, a second meeting was held with each supervisor individually and the particular functions and conditions of his area discussed with a job analyst. All employees in a given unit, section or department (depending upon its size) were then called together and again the program was explained. Following the explanation, a form known as an employee position description, was given to each person with suitable written instructions and a letter of introduction signed by the appropriate division head or vice president. This form, Figure 1, was used by the employee to list his duties and his opinion of the requirements and working conditions of his job. The forms were filled out during business hours or could be taken home for completion. During this period job analysts were available for help in the given area and when not assisting employees or answering questions, were gathering data concerning the general functions and procedures of the particular activity. Upon leaving a given department, the job analyst was required to

Figure 4 — The factors are accompanied by a degree system, also carrying a point value, which measures the adverse conditions under which the employee must do his job.

C-WORKING CONDITIONS

8. Adverse Working Conditions

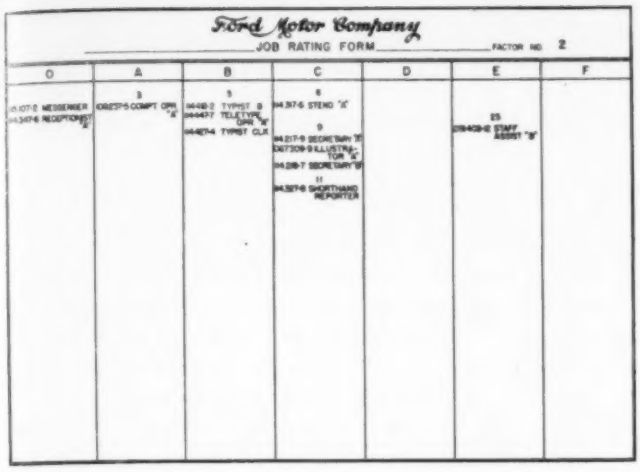
Under this factor, consider those physical conditions surrounding the work performed that are disagreeable, uncomfortable, or otherwise adverse in nature, such as necessary exposure to heat and cold dampness, noise, dirt, vibration, dust, fumes and the like, and the degree and frequency to which these occur.

Degree		Point Value
	Work performed under ordinary, average working conditions. Work under fair plant, field, shop, or office conditions, involving from time to time some slightly disagreeable features, but not to any disturbing degree.	0
A	Work having only occassional or infrequent, and moderately disagreeable features.	1
B	Work having some definitely disagreeable features, that may be fairly frequent, or extended over considerable portions of the work period.	2
C	Work having fairly continuous exposure to some disagreeable feature to a considerable degree.	3
D	Work having some one or two disagreeable features to an extreme degree, for limited portions of the work period.	4-5
E	Work having several highly disagreeable working conditions, extending over major portions of the work period.	6-7
F	Work involving continual exposure to extremely disagreeable work conditions.	8-9-10

Job classifications that are representative for the various point values under factor 8, are listed below. These are bench mark jobs for evaluation of new jobs under this factor only, i.e., the degree to which physical conditions surrounding the worker are adverse in their nature.

BENCH MARK JOBS

Code Number	Job Title	Degree	Point Value
065.307-8	Librarian A	0	0
023.708-9	Chemist, Industrial Waste	A	1
108.697-9	Tabulating Equipment Operator A	B	2
093.217-15	Labor Relations Representative A	C	3
075.767-13	Safety Inspector	D	4
		D	5
093.446-11	Rate Adjusters Senior B A	E	6


Ford Motor Company

JOB RATING FORM _____ FACTOR NO. 2

O	A	B	C	D	E	F
1	3	5	6		25	
7	4	7	9			
			11			

Figure 5 — The job rating form is used to compare the ratings of one job with another one.

prepare a short statement of the functions of the department and to collect representative forms used in that activity. A successful and clear job analysis can be prepared only when all of the facts are known and the requirements placed on the analyst compelled him to become familiar with problems of procedure and function in each department.

Upon completion of the employee position descriptions by each employee, they were reviewed by the job analyst with the appropriate supervisor. This review was carried on for the purpose of ensuring accurate information. In no event was the supervisor permitted to change any information given by the employee although he could make marginal notes or correct a misstatement through discussion with the employee and the analyst.

Upon the collection and review of the employee position descriptions, they were reviewed on a department basis by the analyst and those covering apparently similar jobs were grouped together. For example, if one department had a number of stenographers all taking dictation and typing communications, the individual employee position descriptions were placed in one group for consideration as one job.

Upon the review and grouping of the employee position descriptions, tentative job analyses were prepared by the analysts (Figure 2). These, covering the duties of each job, and outlining the factor requirements, were prepared on the basis of the information contained in the employee position description, the information obtained from the supervisor and upon the knowledge that the analyst had gained from actual job observation. The tentative job analysis form or job description, was then reviewed by a member of the job analysis staff and returned to the proper supervisor for his approval. In many instances, an experienced employee was called in by the supervisor for his comment on the accuracy of the description and where necessary, corrections or other changes were made. With the initialing of the analysis by the supervisor, the job was then ready for preliminary rating by the job analysis staff.

As represented by Figure 3, the Ford program of evaluation is based on a set of fifteen factors. The factors used and the distribution of points over them was developed by the consulting firm through 30 years experience in literally hundreds of firms and thousands of jobs. The authorities are not in agreement as to the most perfect number of factors that should be used nor the manner in which point values should be weighted or distributed and no claim is made that this lineup of factors is perfected. This set of factors and point values are satisfactory in our program, however, and are being used successfully.

Each of the fifteen factors is accompanied by a set of definitions of degrees, each degree having a certain point value. This is portrayed on Figure 4 which is a reproduction of the factor of adverse working conditions with a total or maximum point value of ten points.

As on all other factors, each job and the information contained in the analysis was compared to the degree definitions of this factor and the appropriate definition selected. The job was then compared to all other jobs which were rated in the same degree on this factor and final determination of relationship obtained. In some instances, a given degree has a spread of point values. For example, degree F has a spread of 10 points. In these instances, appropriate assignment of points was made by comparing each job to all other jobs falling

Ford Motor Company — SUMMARY OF POINT RATINGS

DIVISION Any Division — DEPARTMENT Any Department

FILE NO.	TITLE OF POSITION	TOTAL	A. EXPERIENCE KNOWLEDGE AND SKILL				B. WORK COMPLEXITIES				C. WORKING CONDITIONS		D. CONTACTS		E. RESPONSIBILITIES				
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
	SECRETARY "A"	83	19	9	5	2	18	5	0	0	7	4	0	1	6	5	2		
	STENOGRAPHER "A"	48	10	6	3	2	12	2	0	2	4	2	0	0	2	3	0		
	MESSENGER	18	0	0	0	3	4	2	2	1	1	2	0	0	1	2	0		
	TYPIST "B"	17	0	5	2	2	3	1	0	2	0	1	0	0	1	0	0		
	STAFF ASST "B"	110	22	25	0	0	30	9	0	0	10	4	0	0	5	5	0		
	ILLUSTRATOR "A"	78	19	9	10	3	20	6	0	0	0	2	0	0	3	6	0		
	SHORTHAND REPORTER	71	16	11	5	2	15	6	4	2	2	1	0	0	5	2	0		
	TELETYPE OPR. "A"	54	16	5	6	2	13	3	0	2	1	2	0	0	1	3	0		
	RECEPTIONIST "A"	49	10	0	1	1	18	5	0	0	5	3	2	0	0	4	0		
	COMPTOMETER OPR. "A"	41	10	3	3	2	10	4	0	2	0	2	0	0	2	3	0		
	TYPIST CLERK	32	8	5	3	2	6	1	0	2	0	2	0	0	1	2	0		
	SECRETARY "B"	61	13	9	4	2	15	3	0	0	4	3	0	1	4	3	0		

Figure 6 — The summary of a rating sheet enables one to compare one job with another.

into that factor degree and by making appropriate point assignments.

As a further aid in the rating procedure, we used a factor comparison chart, Figure 5. This chart provided a means of listing all jobs by factor and reflecting jobs falling into the same degree of definition. Its use permitted making practical comparisons of one job to another, and to validating the initial interpretation of the degree definitions.

Figure 6 represents a summary of point rating sheet. As each job was given its factor ratings, these were listed and totalled on the chart. Again it was possible to review not only the individual factor values, but to check the total point values assigned the various jobs.

This method of rating resulted in a cross checking procedure which brought to light inconsistencies which would have gone unnoticed had a mere point rating system been used. It further permitted a comparison of totally dissimilar jobs and a later justification of the preliminary ratings.

As a final step in the rating procedure, job comparison charts were prepared for each department and division. As portrayed on Figure 7, these listed all of the

sections in a given department or all departments in a given division and showed all jobs in that area grouped into grades on the basis of their total point values.

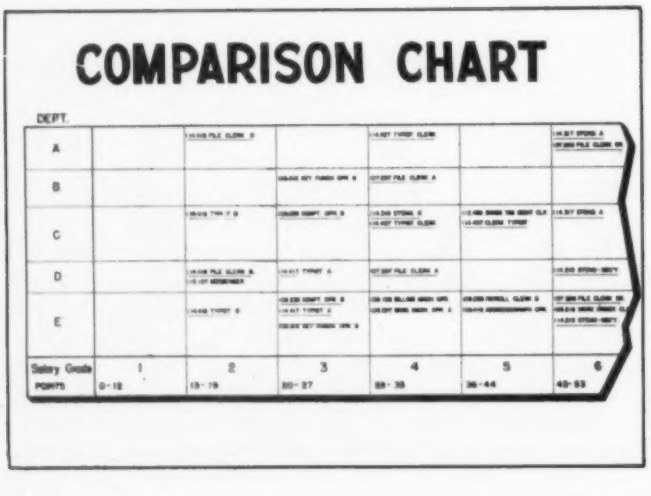
At this point, it should be explained that the selection of the number of grades and the point values of those grades were developed on the basis of a trial run conducted in the early phases of the program on over some 150 representative jobs. Well known "bench mark" jobs such as typists and stenographers, accountants and the like were selected and given preliminary ratings. They were then listed in point value order and natural groupings observed. Without going into all of the technical aspects of this step, a total of 29 grades were set up with an increasing number of points assigned to the higher grades.

With the preparation of Figure 7, the material was presented to the appropriate department head and his subordinates. Each job was discussed, the duties reviewed and if necessary, identified with the employee from whom the original information was obtained. It was at this point that the accuracy of the "scientific" method met the test of the practical experience and judgment. Although some changes were made at this point of review, it was found that in the majority of the cases, the initial rating was found agreeable particularly after all factors were explained, and the jobs re-examined.

To complete the review and approval by supervision, the material from one department was combined with that of the rest in the particular division, charts were again prepared, and the entire picture presented to the division head and his department heads.

With the approval gained, the task of reclassification of employees in the particular division was begun. Each supervisor was visited by an analyst equipped with a list of his employees. Each was discussed, his present duties were compared to the job descriptions and an appropriate classification selected. In all instances this was done on the basis of job duties alone and no consideration was given to the present salary of the employee. This is mentioned merely to point out that up to this step all analysis and evaluation was made without knowledge by the analysts of the salaries being paid the individuals.

Figure 7 — The comparison chart was given to the department head so that he could go over the ratings made by the job analyst to compare his department with the others in the company.



With completion of the reclassification, appropriate changes were made in the personnel records and salary information was collected. Appropriate trend line or scatter charts were then prepared. See Figure 8. Actual salaries paid were represented on the vertical axis whereas the jobs themselves were listed in rising point order along the horizontal axis. By mathematical formula, a line was developed to reflect the trend of the actual salaries then being paid.

At this step we could begin to detect existing salary inequities and to make plans for their correction. The formation of the chart also permitted us to check our scientific method once more against actual experience and practice. Our company has been in existence for a long time and has had to compete with others in the area for workers. The preparation of the scatter chart listing all jobs in their relative positions to and the posting of the actual salaries being paid permitted us to compare our rating to the salaries which actual conditions required us to pay.

Concurrent with the preparation of the scatter charts we conducted salary surveys among other companies in the Detroit area, using our jobs as standards. Each survey was conducted through personal interviews and each job was discussed for comparison with similar jobs in the outside company. Salary and employee information was obtained. The material gathered was then charted in a manner similar to our trend line chart and by comparison we were able to determine the relative position of the actual Ford salary structure to other companies in the area.

As a final step, all available information is being gathered together, and a series of recommendations will be made to top management for the adoption of a set of salary grades.

Although this step has not yet been completed at Ford, the company is now operating with a set of tentative grades that were developed as numbers of jobs were rated and actual salaries charted.

As a brief comment on a salary structure, each company must adopt a structure best suited to its needs and present conditions. No structure, no matter how perfect technically or mathematically, can be used if its installation will result in a wholesale reduction of salaries or lessening of employee morale for other reasons. In most companies installing a new program for the first time, many salary inequities are revealed which can be corrected only through careful study and handling. Many times only the passage of the years will bring salaries into line and conditions will be corrected as employees leave or are retired. The fact that these inequities are brought to light will permit intelligent handling of them and prevent further aggravation of a bad situation. Further, a clear picture of salary conditions will permit the study and the adoption of a more intelligent salary administration program embracing such things as uniform hiring rates, periodic merit increases, and salary cost control between departments, divisions and plants.

As a final but important function of the job analysis and evaluation program, a maintenance or follow-up procedure was set up. Jobs and job values are constantly changing through the effects of reorganizations, development of new methods and the shifting of per-

sonnel and functions. Accordingly the entire structure, both as to classifications, job descriptions and salary structure must be constantly reviewed and brought up to date.

Our program provides that any job or the duties of any employee may be reviewed upon the request of the supervisor. The supervisor and the employee are interviewed by an analyst and if necessary a completely new job is prepared using the same method of analysis and evaluation as previously described. In addition, 30 days after a new employee enters the company or 30 days after a present employee has his classification changed through promotion, transfer, or change of duties, his job is reviewed to determine the appropriateness of his classification. If incorrect, the classification is changed to another existing one or a new job is written.

In summation, to those who may be considering the installation of a job analysis and evaluation program, the following observations should be considered:

Before embarking on a costly and lengthy program, study your own organization and its salary and classification structure. Decide what the problems are and establish definitely what you want and expect to accomplish. With this done, you will be able to select the type of program you need and to establish its scope. Decide also, whether your organization is competent to carry on the entire program or whether you will need the services of outside consultants or management engineers.

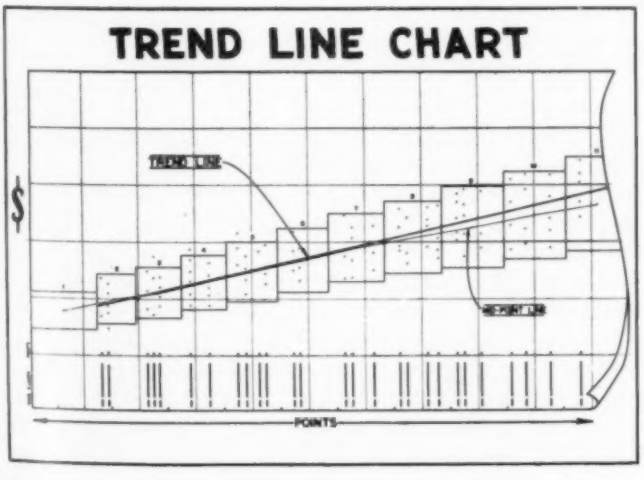
Secondly, after selecting your program, insure the understanding and acceptance of your employees and supervisors by proper introduction. Although the purposes of the program may vary your procedure, it is generally of benefit to provide for employee and supervisory participation according to their level in the company.

Thirdly, remember that best results can be obtained if the installation of the program and the administration of it can be done by your own personnel. Wherever possible the actual analysis and rating should be done by the line organization with the guidance of your staff organization and consultant.

Do not expect that the job analysis and evaluation program will provide an immediate cure to all salary ills. Again it is but a tool and at best will only provide information for use in setting up or conducting a comprehensive personnel management and salary administration program. Finally, upon completion of your program installation, prepare for constant administration, maintenance, review and adjustment. Conditions change constantly and job classifications, job descriptions, salary structures and salary payments must be up to date if they are to be effective.

These are basic rules of operation and no job analysis program will be entirely successful nor endure unless they are accomplished.

Figure 8 — The trend line chart develops a means by which salaries can be tied in with the point rating system.



DISCUSSION

PRESENTED BY

W. J. REILLY, Assistant Manager Steel Operations, Ford Motor Co., Steel Division, River Rouge Plant, Dearborn, Mich.

KENNETH A. DUNN, Supervisor Salaried Personnel, Ford Motor Co., Dearborn, Mich.

PAUL E. KAVANAUGH, Engineer, High Voltage, The Detroit Edison Co., Dearborn, Mich.

E. V. MARTIN, Checker, Great Lakes Steel Corp., Detroit, Mich.

J. LAWRENCE BUELL, JR., District Manager, Reliance Electric and Engineering Co., Detroit, Mich.

W. J. Reilly: During the course of your talk you mentioned two employees working in the same department on exactly the same type of position, and who the job analysis program reveals should be paid approximately the same salary or at least confined to the same salary grade. As a practical matter, what is the solution to the problem if you find that these two men, perhaps because of their length of service, are paid widely different salaries, for example, as much as $200 or $300 difference?

Kenneth A. Dunn: This type of problem is one of the most difficult when found as a result of job analysis and evaluation. The solution, of course, is not to be found in the job analysis and evaluation program, but rather in the manner in which the situation is handled when it is brought to light by the program. We do not claim that job analysis will, of itself, solve these problems. We have found, however, that job analysis does bring to light these situations so that they can be adequately handled by management without a lessening of employee morale.

The best answer that I can give is that when these situations are found they must be handled on an individual basis. A detailed study must be made of the attributes, capabilities and potentialities of the employees involved, particularly the one who is being paid above the established range for his present duties. The ideal situation, of course, is one in which the man who is overpaid has the experience to accept a more responsible position. Lacking this, perhaps he has potentialities which, through training, could be developed so that he could assume a better job. Thirdly, it may well be that the employee is near the retirement age and should be

permitted to remain in his present job at his present salary until such retirement occurs.

Only in extreme instances do we feel that salaries in general should be reduced as a result of the job analysis and evaluation program. Some companies have adopted a policy which permits the reduction of an individual salary only when the individual's job is changed. As long as he remains in the position to which he was assigned at the time the job analysis and evaluation program was conducted, his salary remains as it is even though above the established range. If, on the other hand, he is transferred or is assigned to a job of lesser responsibility, then it is a practice to reduce his salary to the maximum of the salary range in which the new position is assigned. Again, the job analysis program merely discloses situations which need close management scrutiny. Job analysis, in itself, does not provide the solution.

Paul E. Kavanaugh: In the field of salary administration, and more particularly where job analysis and evaluation is used, do you feel that a program can be adopted whereby all employees will be granted automatic salary increases at the expiration of given periods of time? I have heard of such programs, and the question enters by mind as to how employers under such plans recognize individual merit and ability.

Kenneth A. Dunn: The policy of granting automatic increases is perhaps best confined to standard and easily-measured jobs. I have particular reference to positions such as messengers, typists, switch board operators, and the like, wherein an employee's development and proficiency is easily measured. Even in this type of position, however, an employee who is fully experienced, because of such experience is able to perform in a more than highly satisfactory way and, in effect, does a little more than the job requires. This is generally recognized, and for that reason many of the plans providing for automatic increases give such increases only up to a certain dollar amount in the salary spread, perhaps to the midpoint or slightly above. The rest of the range, however, we will say from the midpoint to the maximum, is reserved for the outstanding employee.

A new employee coming in at the minimum, whose development can be accurately gaged, is moved up through the range at certain stipulated periods and in a definite pattern. After reaching a given point in the range, however, further advancement is entirely on the basis of individual merit.

It is my feeling that this type of salary program cannot be applied to the complex positions. Progress in a position of high skill, accountants, engineers, etc., is not always uniform, but depends upon the capabilities of the individuals involved. Two men with exactly the same type of academic background, entering the same job at the same time at the same base salary, will not develop at exactly the same rate. Therefore, in the high type of jobs we recommend that all increases be granted strictly on the basis of individual merit and ability. In this connection, perhaps it would be well to mention that some companies have found programs of efficiency or merit rating to be of great assistance in this phase of salary administration.

Paul E. Kavanaugh: Do you recommend that employees entering a new position always be brought in at the minimum of the assigned salary range?

Kenneth A. Dunn: No. Theoretically, of course, an employee starting on a new job is to be brought in at the minimum. However, we find that in many cases the employees are promoted from one position into another, generally because they have indicated their ability to be worthy of promotion. This fact is taken into consideration in the establishment of the salary ranges.

You will note that there is considerable overlapping of ranges. This permits the promotion of an employee from a salary grade eight job to a salary grade nine job without an attendant adjustment in salary until such time as the employee has proven himself capable. This, of course, takes for granted that the employee, prior to being transferred, is in the upper portion of the original or lower salary grade. The extent to which adjacent salary grades will overlap will vary with the individual salary structures of the companies involved. Generally, however, an employee who has gained considerable experience in a given position has been recognized through merit increases and in all probability is being paid at or slightly above the midpoint of his particular range. The overlap, then, will extend to a little below the midpoint of the lower salary grade. The promotion can be accomplished by transfer to the second job and salary grade without a necessary increase.

Hiring in at the absolute minimum is generally accomplished only in entrance or starting jobs where previous work experience is not a requirement. Even in these positions, however, considerable latitude must be permitted the interviewer or the employing officer to allow hiring in somewhere below the midpoint when the employee has prior experience.

Paul E. Kavanaugh: What could be expected in the way of changes as a result of job analysis and evaluation, in the manner in which merit increases are recommended or approved?

Kenneth A. Dunn: Whether or not changes will occur in the over-all policy of a given company in the manner of handling salary increase recommendations will, of course, vary with the type of procedure and the conditions that existed prior to the installation of the plan. In at least one company of which I have knowledge, supervision, in general, prior to the installation of the job analysis program, was not given the opportunity to effectively administer salaries. Adequate information was not available for them, nor were there any bench marks by which they could effectively gage the progress of their employees or determine their eligibility for salary increases.

A properly administered job analysis and evaluation program will place in the hands of supervision more complete tools, particularly if such a program is coupled with an efficiency rating activity. At any event, the placement of additional and more complete information in the hands of the lower level or first-line supervisors permits them to more intelligently recommend salary adjustments. It is my feeling that the supervisor who is in immediate contact with the employee involved, if not called upon to initiate salary increase recommendations, at least should be given the opportunity to pass on the eligibility of the employee involved. Naturally, more than the approval of the front

line supervisor is required, and the procedure will probably call for final approval by more than one supervisor and perhaps the final approval of the department head or plant manager.

Some companies have established procedures whereby increases up to a certain amount or overall salaries of a certain amount are administered by first line supervision, whereas the higher salaries and major increases require the approval of successively higher members of management including, perhaps, the attention or consideration of a vice president or president of a company.

E. V. Martin: Have you found that a job analysis program tends to lower employee morale during the reclassification period? For example, if you found that two employees, one classified as a senior and the other as a junior, are doing exactly the same type of work, have you found that the reduction of the senior to the junior classification had a disturbing influence on employee morale?

Kenneth A. Dunn: We have found that, in the main, individual employees are very cognizant of their individual classifications and are easily disturbed if the classification change is such as would indicate a lessening of prestige or position. We have, in the past, experienced considerable difficulty in the administration of a classification system employing the words "junior," "intermediate," "senior," etc., in the titles:

In order to avoid foreseeable difficulties, we have abandoned the terms which I have mentioned. The only exception is in the use of the word "senior" which we employ in a type of leader classification. In other words, the term "senior" is applied to an employee who is not a full-fledged supervisor but who nonetheless is assisted by others performing perhaps the same type of job, or is looked to, because of his experience, for instruction and guidance. Rather than use the words, "junior," "senior," etc., to indicate levels, we prefer to designate levels of jobs by the letters "A," "B," "C," "D," etc. This prevents, to some extent, the morale problem you mentioned and, at the same time, sets up a more elastic program of classification.

J. Lawrence Buell, Jr.: In some companies women can go to the top of their organization, but in the average manufacturing company there is a limit to the level of position which a woman can fill. If such a company has a regular program of raises, what is done when a woman's top limit position is reached? Even with the smallest of annual raises, in a matter of 10 or 15 years it would be possible for a woman to exceed her maximum wage classification. I would appreciate your comment as to how such a situation can be met.

Kenneth A. Dunn: As I understand your question you have, in fact, touched upon two problems. First, the employment and payment of female workers and, secondly, the manner of handling employees who have reached or are about to reach the maximum for their assigned salary range. Theoretically, if you are to follow an equitable system of payment, all workers, whether male or female, should be paid on the same basis. In other words, if a female employee in a given job can perform as satisfactorily as a male, she should be paid appropriately. As a practical matter, many companies recognize certain classifications as female jobs exclusively and take care to insure that women are not employed in classifications other than these. At the same time, care is taken to see that males are not included in the female classifications.

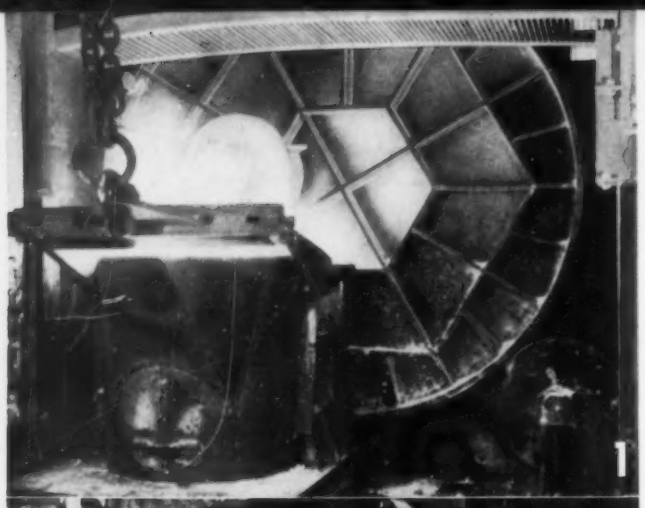
On your second point, that is, the manner in which people at the maximum are to be treated, I would like to point out that the basic theory of job analysis and evaluation is that any given position in the company has a maximum value. This, of course, is regarding the job in an objective fashion with no regard to the individual attributes or personalities of the people involved. Assuming, then, that a given position has a maximum value to the organization, this maximum should not be exceeded under any circumstances. Again, the theory of employing salary ranges or spreads provides for the recognition of better than satisfactory performance, and also for the recognition of length of service. The maximum, however, should not be exceeded no matter what the experience of the employee, so long as that employee is performing the job covered by the particular salary grade.

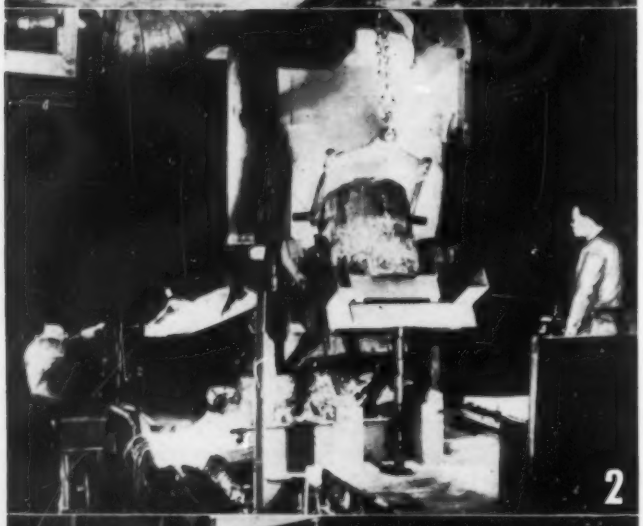
I have found some instances where, in an effort to recognize long-service employees, companies have employed a small percentage of spread above the accepted maximum. For example, assuming that the accepted maximum of a position is $300 per month, provision is sometimes made for the granting of increases or salaries above that maximum to a limited degree of perhaps 5 or 10 per cent. In some cases where employees have 15 or 20 years of service, the over-the-maximum amount is not granted until the matter has been reviewed by an executive or a salary committee. It is easily recognized, however, that a plan of this type merely adds 5 or 10 per cent to the accepted ranges, and the same question will naturally arise when the long-service employee has reached the additional maximum.

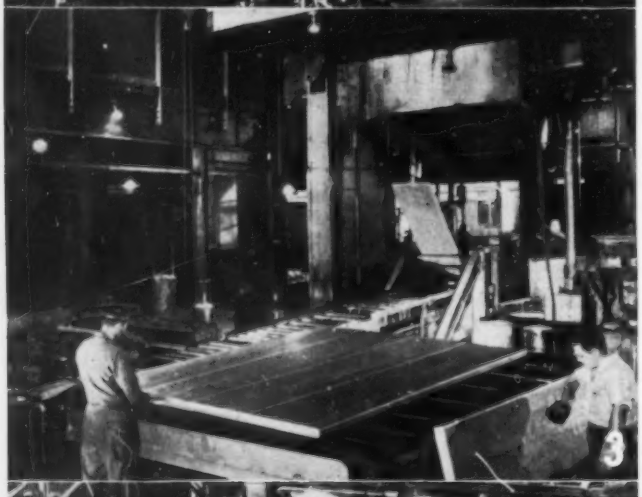
Member: Would you give us your comment as to just how this program in the over-all picture affects morale and production?

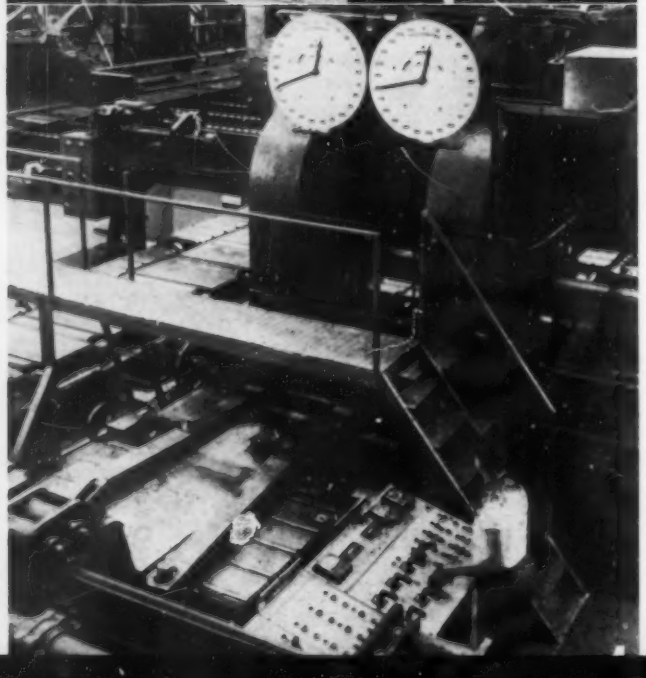
Kenneth A. Dunn: In our company the program has been in existence for about three years. We find, in general, that it has improved morale. As a result of our program, we can intelligently discuss jobs and job duties with employees. We are able to validate their classifications and to explain to them why they have been assigned to an "A" or "B" level position. The company is now in a position to make available to employees and supervisors more job information, than they have ever had before. We are now in a position to intelligently discuss an employee's progress in the company and to point out to him a promotional sequence. Further, through our training department, we are able to establish education and experience requirements for higher level positions, and to recommend to an employee courses of study which will prepare him for advancement.

Perhaps the greatest blow to morale which could arise from the installation of a job analysis and evaluation program would be wholesale salary decreases. Our program has been installed during a period where, through general salary adjustments, etc., the trend has been toward higher salaries. This, coupled with our program to handle over-the-maximum employees as individual cases, has precluded any policy of widespread cuts and we feel has preserved employee morale.









SCOVILL BRASS CONTINUOUS

▲ THE Scovill Manufacturing Co. has just put into operation at a cost of $10,000,000 a production set-up which organizes in straight line flow, all the equipment for producing cold-rolled brass, from the casting of bars to packaging of the finished strip and sheet brass. The unit is based upon the development of a new flat-metal continuous casting machine, and a continuous strip mill, which makes it possible to turn out the heaviest non-welded brass coils ever produced.

① Three 1000-kw electric induction furnaces like the one illustrated are used to melt brass in preparation for continuous casting. They have each a capacity of 10,000 lb per hour and are equipped with the latest devices for precision control of melting.

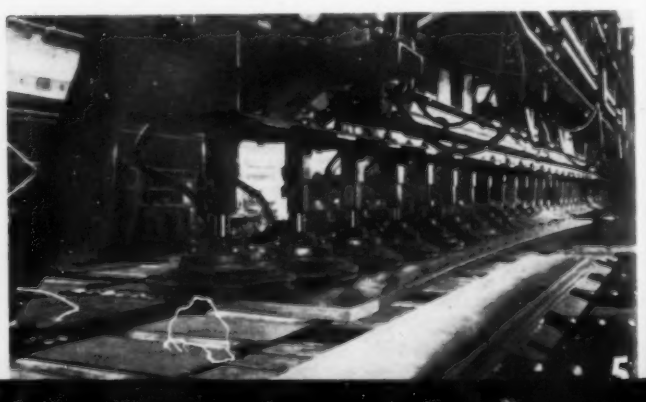
② Approximately every fifteen minutes, the ladle carrying molten brass from one of the three melting furnaces pours its charge into a 9000 lb holding furnace mounted on top of the continuous casting machine. This reservoir supplies a steady flow of molten brass to the casting machine at the correct pouring temperature. Intermixing the charges from the three furnaces provides maximum assurance of uniform composition in the castings.

③ This continuous flat-metal casting machine is the only one of its kind in America for producing flat bars for cold-rolling of brass strip and sheet. This machine not only casts rectangular bars and assures clean, structurally sound metal throughout the entire length of each bar, but produces bar lengths hitherto impossible by any other method.

As the bars emerge from the machine, they are automatically sawed into lengths for delivery to the continuous strip mill. Being of identical lengths, they give equal-length coils during subsequent rolling operations. The conventional gate-shearing or sawing operation is eliminated by this continuous casting process.

Bar corner milling is performed just prior to 2-high breakdown cold rolling to eliminate "fishtail" effect on ends of rolled bars. With this defect eliminated, it is possible to set roll guides close to sides of bar during subsequent rolling operations, and this tight mechanical control holds edgewise camber or "snaking" to the minimum.

④ In the cold breaking-down rolling mill, largest ever built for the non-ferrous metal industry, preliminary rolling operations are carried out. Through a sequence of rolling operations correlated with closely con-



PLANT FEATURES

PROCESSES

trolled annealing practices, the thickness of the cast bars is reduced from 2.500 to 0.400 in. The bars are then ready for surface milling. The 2-high mill is powered by a 2000-hp, a-c motor and will operate at either 90 or 180 fpm. The rolls are 30 x 36 in. forged steel with necks running in sleeve bearings.

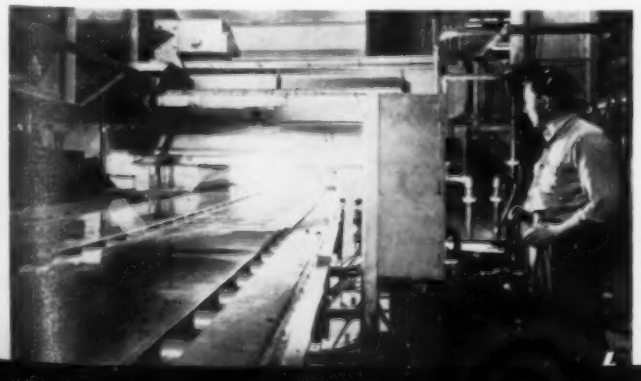
⑤ Since brass is non-magnetic, a vacuum cup system is used to transfer the individual bars to the mill entry table where they are entered in the rolls by a hydraulic pusher or the power feed entry table. On the discharge side of the mill the bars are again stacked by a vacuum cup lift and return by roller conveyor to the entry side of mill or by cross transfer conveyors to end cropping shear and/or long bar annealing furnace or short bar annealing furnace.

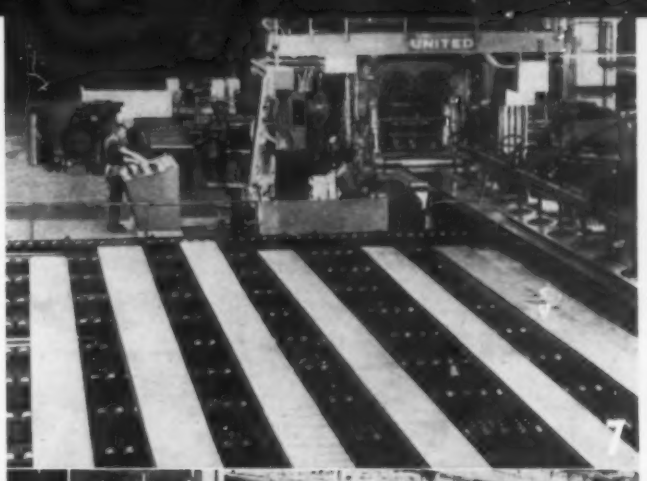
After the last flat rolling pass (approximately 0.400 in. gage followed by an anneal), the metal bars have both flat surfaces milled. This operation is performed in two bar millers. A bar flattener is set up ahead of and in tandem with the first bar miller. After discharge from the first bar miller which mills the bottom side of bar, a turnover and cross transfer conveyor delivers the slab to the entry conveyor of the second miller which runs in the opposite direction. A turnover is provided on the discharge side of the second miller. This set-up allows for a thorough inspection of both milled surfaces.

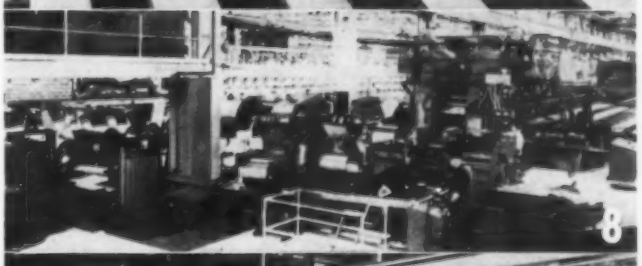
Roller conveyors enable a moving inventory to be carried at all principal processing points in this continuous mill and the constant movement of the material in process toward finishing operations greatly speeds up the production cycle of brass bars.

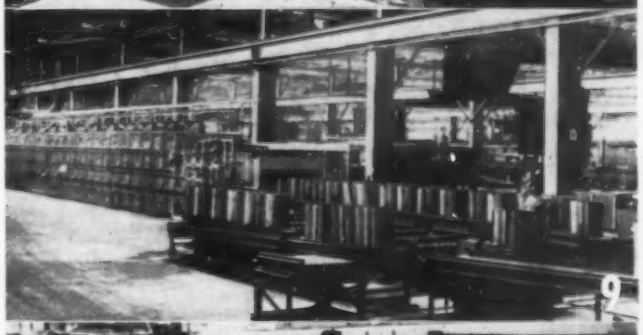
⑥ The four annealing furnaces are all of the roller hearth type. The largest furnace used in conjunction with the 2-high cold rolling mill breakdown operation has a capacity of 33,000 lb of metal per hour. Particularly close temperature controls, including evenness of heat throughout the entire annealing cycle, permit proper cold-rolled reductions to be taken at subsequent rolling points, thus assuring uniform working of the metal. Dual burners were used in the preheat sections to allow for the use of either oil or gas. Propane gas will be used in the heating chambers.

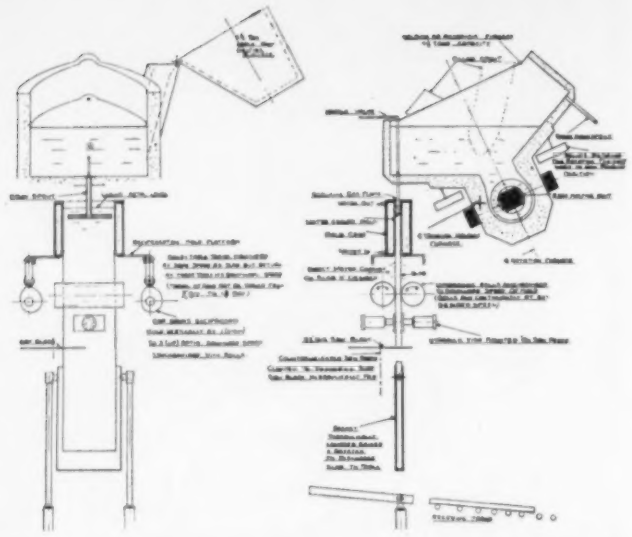
⑦ After surface milling, the bars are delivered to the first of the new 4-high cold rolling mills, designed to produce exceptionally flat brass strip and sheet, and to hold "crown" and "end to end variations" to a minimum. Every known device for precision control and











The continuous casting process developed in the brass industry. A unique feature of this machine is that it forms flat bars for rolling strip and sheet.

quality production is employed, and automatic strip thickness gages hold the thickness of the metal to close tolerances.

⑧ Discharge side of a 4-high cold mill. Flat bars are reduced to approximately 3/8 in. and coiled. Subsequent rolling may continue on this or other 4-high cold mills to the final thickness specified by the customer. Two 4-high single stand rolling mills are used for running down and finishing coiled strip and sheet. These two mills are identical except for certain feeding and take-off equipment. Both mills are powered with 1250-hp, d-c motors and have a top speed of 1000 fpm. The work rolls are 16 x 34 in. forged steel with necks running in tapered roller bearings. The back-up rolls are 34 x 34 in. with necks running in oil-flooded sleeve bearings. These mills are equipped with tension reels, pressure indicators, automatic strip thickness gages, motorized screwdowns, metal lubricators, cooling sprays, oil and water removing devices and other auxiliary equipment designed for high quality rolling of non-ferrous strip.

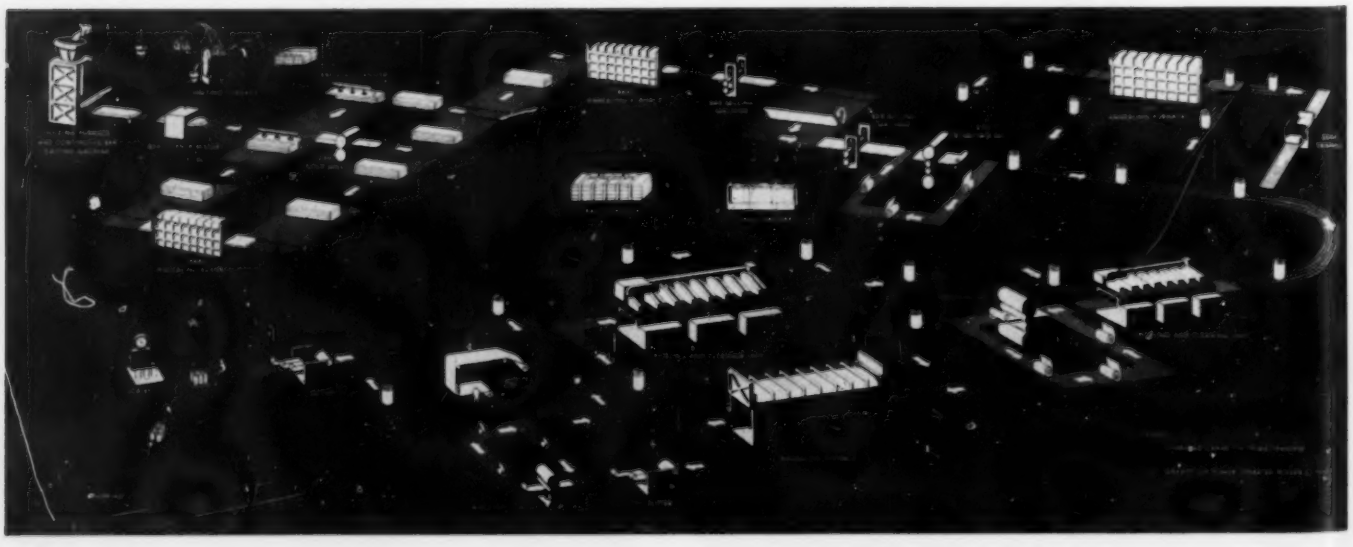
⑨ This roller hearth furnace is designed to process 2000 lb coils of strip, two abreast on inconel perforated metal trays. Flat bars up to 45 ft in length can also be handled. This furnace has a capacity of approximately 33,000 lb of metal per hour with each coil remaining in the furnace from 5 to 6 hr. The pre-heating unit is fired by a dual burner designed to burn either oil or propane gas, with the furnace itself equipped only for the use of propane gas. Temperatures in the furnace range from 250-800 C and are controlled by the radiant pyrometer zonal control system which holds temperatures from coil to coil within a range of 5 C. This precision-controlled furnace produces a clean and uniform anneal for the subsequent required reductions and finish tempers.

⑩ One of the two strip pickling lines which provide for cleaning the surface of the strip after annealing. Each of these lines is over 150 ft long and can handle strip up to 30 in. wide. Each line consists of a coil pay-off reel; feed rolls and metal flattener; a series of sulphuric acid, bichromate, cold water, hot water and soap tanks, and a hot air dryer. A winding reel for light metal and a coiler for heavier strip is installed at the discharge end of the lines. The pickling and rinsing is all done by pressure spraying, and carry-over of liquids from one tank to another is prevented by a series of air jets. There is no stitching of one coil to another in these pickle lines. The lines can be operated at variable speeds to suit the nature of the cleaning required.

⑪ The slitting lines in the new rolling mill addition are built to cover every requirement for slitting non-ferrous metal from 0.004 to 0.375 in. in thickness and up to 30 in. wide. The lighter gages will be slit as a pull-through operation. This reduces the edge chamber to a minimum and improves sharpness of the cut on slit edges. Shears and measuring devices are built into the slitting lines to furnish coil weights to customer requirements.

⑫ At speeds approaching 800 fpm, various narrow width, light gage metals are processed on this specially designed rolling mill. Besides an X-ray thickness gage and motor screwdown control, it has every necessary control device for keeping close dimensional tolerances and uniformity throughout each processed unit of brass strip and sheet.

Straight line flow is a feature of the new brass mill.



Developments

IN THE IRON AND STEEL INDUSTRY

During 1949

By I. E. MADSEN

▲ AS 1949 opened, the steel industry was operating under a huge order backlog which made the cry of "Production and Still More Production" an objective of first priority. Under this stimulus and as a result of the slight slackening of business in the spring, the steel industry finally reached a position in which supplies of steel were in line with demand. As a result, production rates started to drop and some units were closed down until a resumption in business activity and the threat of the steel strike again stimulated demand. If it were not for the steel strike, all production records for a year would probably have been broken, and because of the strike, production resumed after its settlement at a high rate which continued to the end of the year.

One of the factors which helped supply catch up with demand was the initiation of operations at many of the new facilities which have been on order and planned since the end of the war. As a result of the expansion, there is now over $1,000,000,000 more invested in the steel industry than there was at the end of 1946, and because of the higher present day costs, average capitalization per ton of ingot capacity is more than 15 per cent higher than it was two years ago.

All records for steel production were broken in the first quarter of 1949 when the output was equivalent to an annual figure of 1,300 lb of raw steel per person in the United States. This rate did not continue.

However, 1949 proved to be the third largest steel production year in history with a total output of about 77,860,943 tons. The year ran the gamut from the highest production in history in the month of March for a total tonnage of 8,387,929 or 102.7 per cent capacity to a low of 926,082 ingot tons or 11.3 per cent of capacity in the month of October. This latter figure was

The jiggling harrow is cutting a slice crosswise from the end of an ore stack. Previously, the layer had been stacked lengthwise by the twin mechanical boom which gives a uniform blend for charging into the blast furnace.

the lowest monthly output since July 1932. One reason this figure is so low by comparison with the previous strike in 1946 is because production of the 1946 general steel strike was split between two calendar months. The loss of steel production because of the recent strike was about 9,000,000 tons. If production had continued at the March rate, over 98,000,000 tons of ingots would have been produced during the year. Finished steel production was about 57,000,000 net tons.

Both the pig iron and steel making capacity of the industry increased during the year. Steel making capacity as of January 1, 1949 was rated at 96,120,930 tons and blast furnace capacity was 70,541,850 tons. The blast furnace capacity at the end of the year increased by about 468,000 tons. Steel capacity at the end of the year increased about 2,462,000 tons (1,103,000 tons open hearth, 693,000 tons electric, and 666,000 tons bessemer). Thus, rated steel capacity at the end of 1949 is about 98,600,000 ingot tons. Only moderate expansion is expected in the steel industry in the next ten years and maximum capacity will not probably exceed 100,000,000 ingot tons. It is expected that about 540,000 tons of capacity will be added in 1950. In 1949, a total of about $627,000,000 was spent on new plants and equipment.

Production of stainless steel in 1949 was lower than the previous all time peak year of 1948. However, these steels accounted for a large portion of the steel industry's nickel consumption. Approximately 60 per cent of the alloy steels produced in 1949 were of the chromium-nickel type.

One factor which helped supply catch up with demand was that steel exports dropped as European production increased. The reduction in the demand for steel is having several important effects. One result is that users are taking steel from nearby mills to reduce freight charges. Another result is more intensive selling on the part of the steel industry. Still another effect has been that some plants were absorbing freight to meet competition and in some cases, although there have been no major price cuts in base prices, there have been some cuts in extras.

The so-called gray market in steel has also virtually disappeared. For the same reasons, distribution through warehouses is going back to the prewar pattern and there has been a drop in the volume of warehouse business. Further evidence that steel is catching up with demand occurred when the Secretary of the Commerce Department asked Congress not to extend voluntary steel allocations as well as the dropping by the companies of their quota limits. In a statement before the American Iron and Steel Institute, the Secretary of Commerce said as follows: "Contrary to any rumor you may have heard, the government never intended to take over steel business of the United States, nor even considered that as a possibility."

Although the government still owns about $150,000,000 of steel plant facilities, most of the government steel plant assets have been liquidated, and the remaining units in general are so situated that they are not apt to be taken over. The government had ended the war with steel plant facilities which cost about $638,000,000, and blast furnaces which cost about $55,000,000. In its sales, the government realized about 33 per cent on its investment. The biggest operator of government owned facilities is the Republic Steel Corp., which has a number of them under lease. During the year, Republic took over the lease to operate the government-owned blast furnace at Cleveland, effective May 1st, and it will continue to operate the unit for the production of merchant iron.

The reduction in steel requirements also made academic the many studies on required ingot capacity versus population and versus that required for full production of the economy of the United States. It is now becoming very apparent that the industry will attain its normal peace-time pattern in which operations will be below actual steel capacity.

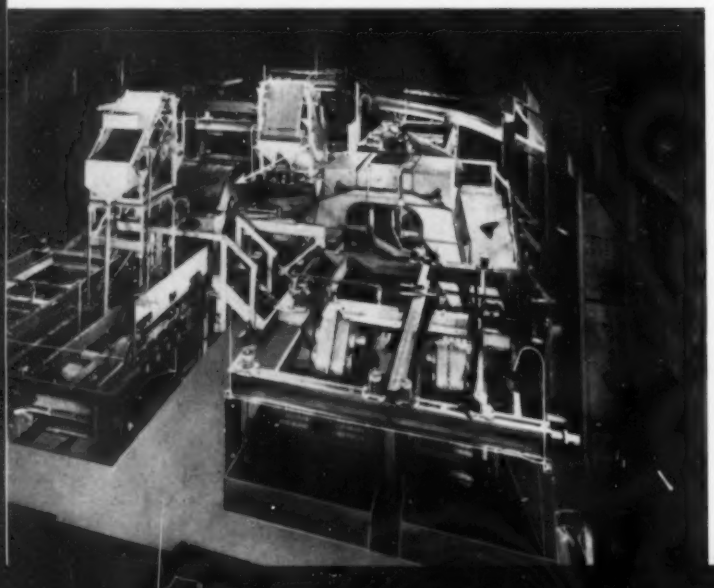
One of the factors which is hardest to develop in any expansion is that of raw materials. In the year 1948, for example, the steel industry used 97,659,000 tons of coal from which 61,000,000 tons of coke were made. The industry also used 23,000,000,000 kwhr and 2,195,539 gal of fuel oil. In addition 296,325,000 gal of tar and pitch were used as well as 274,500,000,000 cu ft of natural gas. Also used in 1948 for alloying purposes were 212,000,000 lb of metallic chromium, 76,000,000 lb of nickel and 16,000,000 lb of molybdenum. Fluxes used were 6,746,000 tons of which 226,000 tons were fluorspar. With such requirements for raw materials, steel expansion is not to be lightly undertaken.

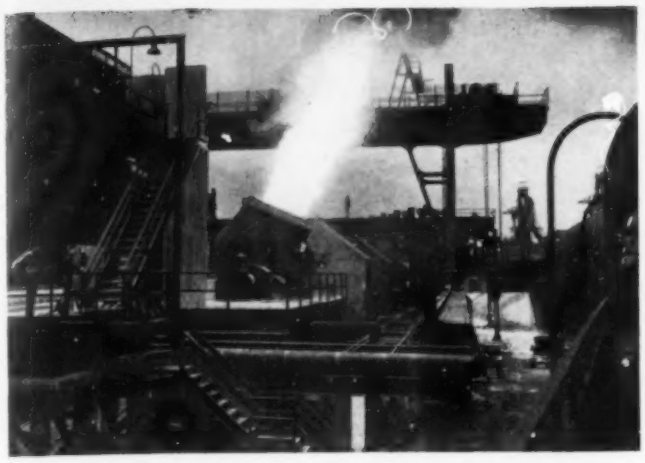
One raw material factor which became plentiful during the year was scrap, and prices broke from a high at the beginning of the year of about $43.00 a ton to a low of about $19.00 a ton and they recovered by the end of the year to a figure of $26.58.

Production in tin, particularly in Malaya, was high and by the end of the year the supply had been brought in line with demand. This was demonstrated by the break in tin prices which took effect toward the end of the year. Tin production in 1949 was probably not far short of the 1939 figure of 47,000 tons. Production of primary aluminum in the United States was slightly over 1,200,000,000 lb in 1949, and shipments of aluminum sheet plate and strip were about 800,000,000 lb. This latter figure compares with 1,250,470,000 lb in 1948.

A new material which came to the forefront during

This general view of a heavy media coal cleaning plant shows the arrangement of processors, magnetic separators and drainage screens.





The National Tube Co. has put into operation four bessemer converters similar to the one illustrated at their Lorain plant.

the year was titanium. This metal is strong, having a strength up to 200,000 psi and at the same time it is 40 per cent lighter than steel. In addition, the metal has high resistance to corrosion and initial tests indicate that titanium alloys are more resistant than stainless, monel and copper-nickel alloys. However, production is very expensive and difficult. Ingots as large as 400 lbs were produced by a steel company during the year which were much greater than the 1 to 5 lb batches which had been previously made. At the present time, prices range from $5.00 to $20.00 a lb.

One factor in the raw material situation has been the possibility of losing foreign sources. This possibility was brought out when Russia cut off manganese ore shipments to the United States for a period of two months. Although there has been some alarm on possible shortages of manganese, additional supplies can be obtained fairly easily from South Africa; and with development work (mostly transportation equipment) Brazil can produce a great deal more manganese ore. In addition, steel men in an emergency could operate furnaces at their present capacity using only 75 to 80 per cent of their present requirements. It is also possible to change specifications to require less manganese.

Pointing the answer to the one solution of the manganese problem is a research project which is under way by the Bureau of Mines and the American Iron and Steel Institute to develop means by which manganese can be recovered from the runoff or flush slag which contains about 11 per cent manganese. The method involves converting the flush slag in blast furnaces to a high phosphorus spiegeleisen (about 30 per cent manganese). Next, oxidation of the manganese from the molten spiegeleisen will produce an ore with about 55 per cent manganese but low in phosphorus, and third, conversion of this ore in another blast furnace to produce 80 per cent ferromanganese. The flush slag has a potential source of about 400,000 tons of manganese, and this would be sufficient to take care of about 80 per cent of the manganese requirements.

Another process for recovering the manganese has been developed by a Cleveland concern. In this process, the slag is passed through a crusher and a gas fired kiln, and then through a number of other steps which are similar to ordinary mineral techniques. The inventors of this method believe that recovery plants handling about 300 tons of open hearth slag a day would provide an economical operation. A small pilot plant with about 15 tons daily capacity is now being planned.

A third possible source of manganese may be provided by a new process for the production of manganese oxide concentrate inasmuch as this country has large reserves of low grade manganese ores. The process involves leaching ground ore in pickle liquor, and the sulphate solution is then separated from the gangue. The sulphate is then converted to a chloride by treatment with calcium chloride and the precipitated calcium sulphate is prepared by filtration. The best proportion of iron is separated from the solution by differential precipitation, and finally the manganese is precipitated from the solution with a high calcium lime slurry. It is claimed that the process requires only the simplest kind of equipment.

Some of the marginal steel plants which were purchased by users in order to insure a supply of steel have been having their difficulties with the return of the competitive market. As an example, production was discontinued at the Phoenix Apollo Steel Co., Apollo, Pa., although the hand mills were started again after the steel strike on a temporary basis. The Hudson Motor Co. terminated sheet production at the Valley Manufacturing Company's New Castle plant. The Borg-Warner Corp., Superior Sheet Steel Division Plant, Canton, Ohio, has been idle since July. The General Electric Co.'s, Mahoning Valley Steel Co. plant at Niles, Ohio, is operating on a curtailed basis.

The Phoenix Apollo Steel Co. plant at Phoenixville, Pa. was purchased by the Barium Steel Corp., who also purchased the Phoenix Bridge Co. These will be operated as wholly owned subsidiaries of Central Iron and Steel Co., Harrisburg, Pa. The Empire Steel Corp. was sold by the Studebaker Corp. to the Rema Co. of Dover, Ohio. A $10,000,000 improvement program is contemplated.

Many steel companies are now pushing new production developments and some companies have started production on types of steel which their competitors have found worthwhile. These changes, however, are as yet only being felt gradually by the industry. As an example, the U. S. Steel Corp., which spends about $10,000,000 a year on research, is working on steel prefabricated houses and new alloys, in addition to the many programs which involve production.

Outstanding developments for the steel industry during the year were not in the field of operations but in the field of labor relations. The steel unions finally obtained their objective of pensions, completely financed by the companies. The plans vary but in general they follow the so-called Bethlehem pattern which gives the worker a minimum of $100.00, including Federal Social Security, after twenty-five years of service. The workers also obtained additional social insurance benefits to which they are making a contribution. Because of the many variables involved, no one yet knows what the cost of this pension will finally be or what its effect will be on steel prices.

It has been estimated, however, that the cost of the

pension may run as much as $4.00 per ton, although this is tentative as yet.

At the end of the year most companies announced price increases which will have an overall effect of increasing steel prices about 4 per cent. All prices were not increased, and as a matter of fact the prices of tin mill products were reduced about $3.30 a ton. The price increase was charged to higher production costs, including the cost resulting from the new insurance and pension programs. As a result of price rises, the composite index at the end of the year was 3.836¢ per lb compared with 3.720¢ per lb one year ago. (Iron Age). The elimination of the gray market and the ability to purchase steel from the closest or more economical plant results in the net reduction in the overall cost of steel to some buyers.

The payroll in the iron and steel industry for the first nine months of 1949 was the highest ever for this period with a figure of $1,670,000,000. In the month of September, the average hourly payments were $1.712 and wage earners worked an average of 36.8 hr per week. Estimated employment for the month was 600,200. Wage earnings are now 116 per cent higher than they were in 1939, and this does not include insurance and pension benefits. One bright factor in labor costs is that accidents are gradually going down. Steel workers had fewer accidents in 1948 than they have ever had before. The rate was 5.86 accidents per million man hours worked in this year.

Because of higher cost operations, breakeven points were difficult to determine, but some producers are using a figure of about 75 per cent as a breakeven point, and some of the evidence presented before the steel Fact Finding Board indicates that when production drops below 60 per cent, some of the firms will go into the red. Hiland G. Batcheller, chairman of the board, Allegheny Ludlum Steel Corp., stated that under present conditions his company's breakeven point is around 60 per cent of capacity, and this is borne out by reports of the company for the second quarter which shows the company just breaking even with operations at 60 per cent.

In the so-called cement case, the Supreme Court upheld the Federal Trade Commission in their attempt to force the cement industry to abolish the basing point system. Inasmuch as the procedure in the steel industry was essentially the same, the steel industry immediately abolished this procedure also. Since the abolishment of the basing point system, a number of bills have been introduced into Congress but none have been enacted as yet. The trend seems to be to legalize the individual use of delivered pricing, with good faith made the sole issue on price discrimination. It had been hoped that a solution would be reached on the basing point controversy before the end of the year. The steel industry had offered to accept a consent degree in settlement of the Federal Trade Commission's action against the industry's former multiple basing point delivered price system. It first appeared that this would be agreed to by the FTC. A deadlock arose in this controversy when two FTC attorneys disagreed on whether to accept the steel companies proposal. Final decision will be left in all probability either to the President or to Congress who may have to pass legislation to settle the issue. Selling and buying of steel under the new freight absorption bill has become much more tricky than previously.

The open hearth illustrated is located in Japan. The furnace has no buckstays and any or all of the doors can be opened resulting in a clear opening up to 21 ft. Notice that the molds being charged are resting crosswise, something which cannot be done with the ordinary furnace.

One effect, not entirely expected with the advent of mill pricing, has been the movement on the part of steel users to set up plants in areas which may have a surplus of steel capacity such as Pittsburgh. A number of new plants have found it economical to move to this area.

One trend in the steel industry accelerated during the year is toward truck shipment of steel. One of the causes was the abandonment by the steel industry of its basing point pricing system in favor of f.o.b. mill pricing. The increase in truck shipment over the year before was approximately 30 per cent. The increase in freight rates also accentuated this trend, and place centers such as Pittsburgh at a further rate disadvantage on shipments into major consuming areas such as Detroit.

Freight increases in 1949 were 6 per cent and result in an average increase of $4.00 in steel prices to consumers. Included in this figure is an addition of $3.50 to the cost of making a ton of finished steel because of added freight rates.

Expansion of plant capacity went on during the year, and the world's first continuous seamless tube mill started rolling at the National Tube Co.'s Lorain works. The Geneva Steel Co. completed conversion of its facilities to the manufacture of hot rolled coils to supply the new cold reduction and tin plate mill of the Columbia Steel Co. at Pittsburg, Calif. The American Steel & Wire Co. completed concentration of its stainless steel wire drawing facilities at Waukegan. Carnegie-Illinois Steel Corp. was operating its new rolling facilities at Gary and Irvin as well as the new silicon sheet facilities at Vandergrift. A heavy gage continuous galvanizing line is also in operation at the Irvin Works. Kaiser put an additional blast furnace into operation at Fontana.

During the year, the Granite City Steel Co. ended its 15-year modernization program which has cost the firm $20,000,000. The firm has now completely switched from the old hand rolling mills, of which it had 42 at one time. The work is now being done by a new tandem cold reduction mill which can roll about 50 tons of steel an hour.

Extensive expansion programs are being planned by the Lone Star Steel Co. which is expecting to spend

$52,500,000 on a mill in eastern Texas. Another new expansion program announced was that of the Portsmouth Steel Corp. which was purchased during the year by the Detroit Steel Corp. It is planned that a hot rolled sheet and strip mill, and an electric weld pipe mill will be put in operation at Portsmouth, Ohio.

One trend which has showed up in the industry has been the movement of pipe-making facilities to the point of use. The A. O. Smith Corp. announced that it will build a pipe mill in Houston, Texas, which will produce welded casing line pipe from 8⅜ to 30 in. in diameter and larger. The operator will be the Sheffield Steel Corp. The mill is estimated to cost $5,000,000 and will have a capacity of 30,000 to 35,000 tons a month, and on that basis will be the second largest welded pipe mill in the world.

A few weeks later, the Consolidated Western Steel Corp. announced that it would also build a $5,000,000 mill to make electric welded steel pipe. The new mill will have a capacity of 100,000 net tons of 24 in. pipe a year and will also be able to make pipe as large as 36 in. in diameter.

Another expansion program in the West was completed when the Colorado Fuel and Iron Corp. put into operation its $5,200,000, 27-stand rod mill at its Pueblo, Colo. plant. This mill is part of a $10,000,000 expansion taking place at the Colorado division. The rod mill with its supplemental facilities will bring total annual capacity of the plant up to 180,000 tons.

As a result of these expansions in the West, steel production has now been increased five-fold in the past ten years. The states of Colorado, Utah, Washington, Oregon and California now make 5.3 per cent of the nation's raw steel. One plant alone, Fontana, made a million tons of ingots during the year (first time on the Pacific Coast). The increase of steel capacity in the western states during 1949 alone is about 700,000 net tons. The increase has been planned to bring capacity up to production but the growth in the West has been so large that present capacity is still probably short of requirements.

Serious consideration is being given to the possibility of constructing an integrated steel plant in New England which will produce 1,250,000 tons of ingots yearly and have a capacity of 1,000,000 tons of finished steel. The final production is to be hot and cold rolled sheet, hot rolled bars and light plates. The project, if it goes through, will probably be owned by a public authority and operated by an existing steel maker. The estimated cost of the project is $225,000,000. Ore will probably come from foreign sources, perhaps the new Labrador ore deposits, and coal would move by water from the Hampton Roads, Va. area. The plans for this steel mill received a setback when four of the largest steel companies in the Pittsburgh district turned it down as impractical after each made an individual study. These companies were the United States Steel Corp., Jones and Laughlin Steel Corp., Republic Steel Corp., and the Youngstown Sheet and Tube Co. The plant was to have gone into production in January 1953. The proposed sites were New London, Conn., Portsmouth, N. H., and Hingham, Mass., all seaboard sites. New Hampshire officials were still negotiating with the Allegheny Ludlum Steel Corp. on the possibility of the latter establishing such a plant at Portsmouth, N. H.

This new 54-in., 4-stand, tandem, cold reduction mill was part of an expansion project in the Chicago area.

At the end of the year, the Carnegie-Illinois Steel Corp. announced that it was acquiring a 3,800 acre tract of land in Pennsylvania thirty miles northeast of Philadelphia on the Delaware River for possible future use as a site for an eastern seaboard steel mill. The construction of a mill, however, has not been authorized.

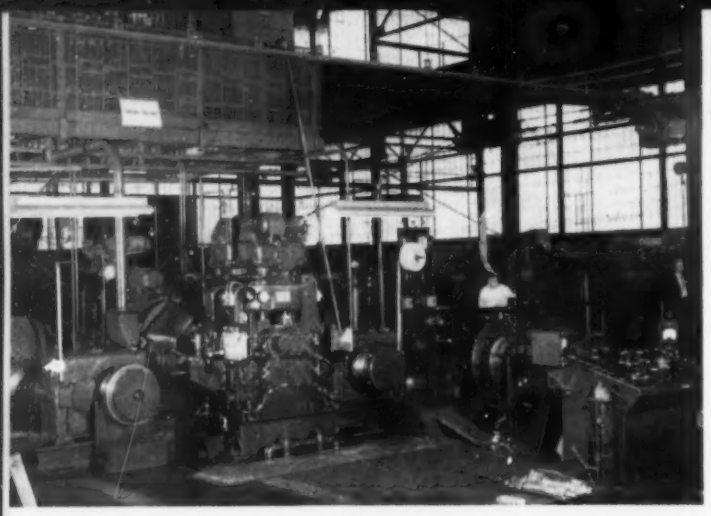
A great deal of expansion has been authorized in Europe, much of which has been aided by the ECA program. Some of this expansion took place before the establishment of the ERP, and these previous projects include:

1. An 80-in. continuous strip mill for the Steel Company of South Wales.
2. A 66-in. continuous strip mill for France at Denain.
3. Two semi-continuous strip mills for Belgium.
4. An 80-in. semi-continuous strip mill for Italy.
5. A seamless tubing mill for Stewarts and Lloyds in England.

Under the ECA, expenditures for the following projects have been approved by the steel committee of the OEEC for:

1. $5,000,000 for 66-in. continuous hot and cold strip mills at Denain, France with a capacity of 600,000 tons a year of flat rolled products. This is same mill as in previous paragraph.
2. $4,100,000 for a blooming mill for Austria with a capacity of 480,000 tons a year.
3. $690,000 initial payment for a reversing cold mill at Bass Indre in France to provide capacity for the production of 50,000 tons of tin plate a year.
4. $50,000,000 for purchase of U.S. equipment for an 80-in. continuous hot strip mill, and a 42-in., 5-stand cold strip mill at Hayange and Ebange in the Lorraine. Estimated total cost of project is $137,000,000 which is to be operated by a combination of nine firms called Sollac. Annual capacity of hot mill will be 700,000 tons, of cold mill 350,000 tons. A 3-stand 80 or 60-in. cold mill is also under consideration for this project.
5. $12,000,000 to Italy for a reconstruction and modernization program at Bagnoli and Piombina, Italy. Both plants are subsidiaries of Finsider.

The exact status of the steel program in Europe is extremely complicated and will vary as plans, estimates, authorizations and justifications are made, sub-



The cluster mill gives the rolling mill operator an opportunity to obtain the larger reductions given by small work rolls.

mitted, and approved by the OEEC. However, the total estimated import requirements alone for the program for the years 1948 to 1953 for Austria, Benelux, Denmark, France, Greece, Italy, Norway, Portugal, United Kingdom, Sweden, and Turkey total $544,446,000 of which $363,367,000 worth will come from the United States. The program at the present time is still in a very preliminary stage but finished steel production is now up to about 37,800,000 tons compared with 34,000,000 one year ago. It is estimated that the final program will provide finished steel production of 44,300,000 tons by 1952 or 1953. This compares with the 1935-38 average of 31,500,000 tons. Ingot production will be 57,600,000 tons in 1952-53. The total overall cost of the program is estimated at the equivalent of about $3,100,000,000.

The British iron and steel expansion program which is under way will cost over $1,000,000,000 and will result in pig iron capacity of 14,560,000 net tons (an addition of 2,800,000 tons) by 1953, and also result in a steel ingot capacity of 20,700,000 net tons. The largest individual expansion in Europe is at Margam, South Wales plant of the Steel Co. of Wales. French steel production by 1952 under the ECA program will be 14,500,000 ingot tons.

Monthly average production in Europe for the following countries in 1949 were Great Britain, 1,381,000 ingot tons; France, 653,000 ingot tons; Western Germany, 513,000 ingot tons; Belgium and Luxembourg 579,000 ingot tons. Total annual steel production in Great Britain in 1949 was an estimated 17,360,000 net tons compared with 16,662,240 in 1948. Steel production in Italy in 1949 was about 2,228,000 net tons which is about 10,000 tons less than in 1948. Semi-finished steel, however, is slightly higher than the year before.

At the present time, it appears that the British Labor Government will win in their plan to nationalize the iron and steel industry. The only way in which this plan can be stopped will be in the event the conservative government is returned to power in the next general election. The devaluation of the British pound may result in taking some business away from the United States, particularly in South America. One item in which this trend is occurring is tinplate.

Last April 1st, the English government abolished subsidies on freight rates which had been helping the British iron and steel industry, and as a result prices went up about 9 per cent.

In Germany, the Hermann Goering Works started production and the iron will be used for making steel in the Ruhr. At Mo-I-Rana, Norway, an electric pig iron smelting plant is planned. The plant will use 20,000 kw and consumption is expected to be in the range of 2340 kwhr per ton.

Little is known of steel plant developments behind the iron curtain, however, the United States is building a blooming and slabbing mill for a steel plant in Yugoslavia which will cost about $3,000,000.

A survey is now being made for a possible steel plant in western Australia. At the present time there is a good ore field available for development at Koolan Island. Since Australian law does not permit exportation of iron ore and because the Broken Hill Proprietory Co. has sufficient ore sources of its own, it will take a new steel plant development to make use of the available ore. This steel plant will be operated by the Western Steel Enterprises, Ltd.

In the latter part of the year the Itabira Special Steel Co., the most recently organized steel company in Brazil, was authorized to exploit a deposit of manganese in Itabira. The steel plant which is under construction in the area will be ready in 1950.

BLAST FURNACE AND COKE PLANT

The policy of building up large stocks of raw materials at all times kept the blast furnaces going whenever the labor and demand situation permitted. Coal supply was an extremely variable factor during the year because of the various shutdowns, part-time programs and strikes called by John L. Lewis, most of which were attempts to keep coal stocks at low levels in order to improve his bargaining position. Coal, however, never did become a limiting factor in steel production, although it may have done so if the steel strike had not occurred. However, these constant shutdowns and part-time operations can result only in higher prices for coal than what would have been the case if continuous operations could have taken place.

For the first time since the war, business dropped enough so that iron production was cut back at some of the furnaces, and some were taken out of blast because of a lack of demand. This was particularly true in the merchant iron field.

Shipment of iron ore in 1949 was about 13,000,000 tons less than in 1948. However, the winter stockpiles were about 3,000,000 tons ahead of 1948 and this should be more than adequate to carry the mills through the 1949-50 winter season. Ore movement on the lakes were 69,385,549 gross tons compared with last year's record of 82,436,473 tons.

Although coal production was down, one helpful factor was that the quality of the coal seemed to improve over 1948. This is due to the fact that additional coal washing plants went into operation and the operators had more experience with their old washers. Sec-

ondly, better quality commercial coal was available. Although coal improved in 1949, the increase in the sulphur content of the coal has been three-fold in the last ten years and ash content has doubled. The result has been increased limestone requirements and higher coke consumption in the blast furnace. The washing and cleaning of the coal removes about two-thirds of the inorganic sulphur present but it does not remove any of the chemically combined organic sulphur.

A research program is under way at Massachusetts Institute of Technology to determine whether additional sulphur can be removed by the blast furnace slag, and it is hoped that an optimistic answer to this problem will offset some of the additional sulphur which is showing up in the raw materials.

A new approach to determine what actually happens in the blast furnace is being investigated by the use of radio-active isotopes. Of interest is the path of sulphur through the coke oven and blast furnace. Radio-active pyrite is mixed with a charge of coal going into the oven and the course of the pyritic sulphur is then traced to determine how much is evolved in the gas and how much remains in the coke. So far, the investigation indicates that the pyritic and organic sulphur appear in the coke in proportion to their concentration in the coal, and this would lead one to believe there is no satisfactory way at present of reducing the sulphur content of coke by choosing a coal of high or low pyritic or organic sulphur.

From the research project on coal expansion pressure in coke ovens, it has been concluded that no known damage to coke ovens has resulted where pressures have not exceeded 2 psi.

Heavy media separation is finding increasing application in both the coal and ore industries. At the end of the summer, installations were in operation at fourteen plants and nine more were under construction. The largest installation to date is one by Jones and Laughlin Steel Corp. which will treat 1500 tons of bituminous coal an hour. As of June 15, 1949, capacity of heavy-media coal plants in operation was 7,515,800 tons, with about 12,000,000 tons more capacity under construction. At the same time, heavy-media plants were in operation which would treat 3,860,000 tons of iron ore and another 3,950,000 tons capacity was under construction. The heavy-media materials used in iron ore preparation are ferro-silicon and iron oxide, and these will give a range of density from 1.25 to 3.75.

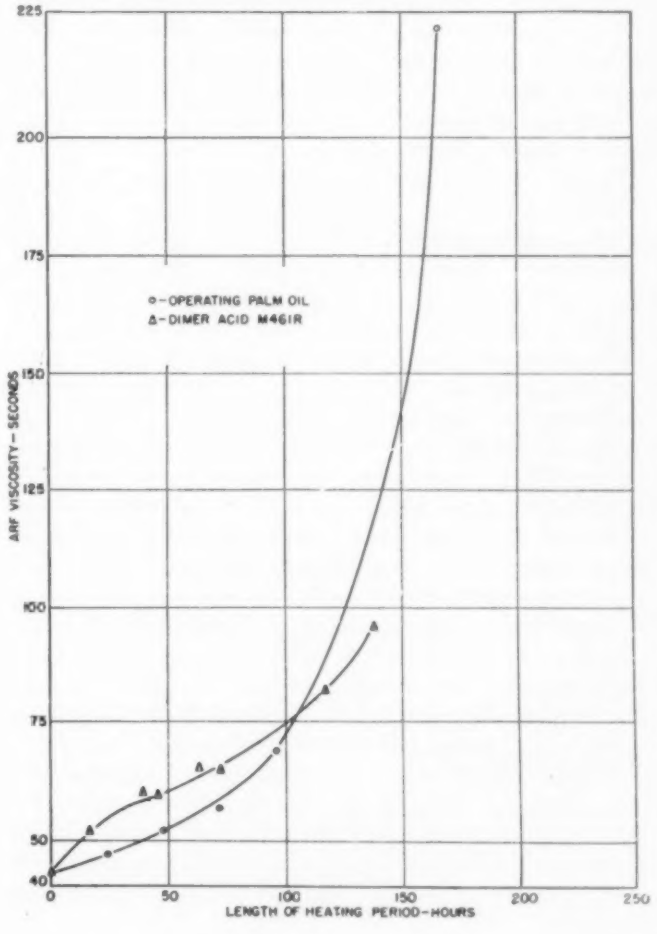
Extensive drilling tests during the year proved a potential new source of more than 30,000,000 tons of high grade coking coal in central Utah. The deposit is now leased from the Department of the Interior by Kaiser Co. The seams are from eleven to fourteen feet thick.

Because of increased pressure, the St. Lawrence seaway project could well be approved by Congress in the near future. The proposed bill under consideration will establish a minimum depth of 27 ft over the entire route from the Gulf of St. Lawrence. One of the factors helping to obtain approval is the fact that the United States may soon need foreign sources of iron ore, and Labrador, Quebec and South America offer such possibilities. A number of American steel companies took an option to participate with Canadian interests in the development of Quebec and Labrador iron ore. The operating company will be the Hollinger-Hanna, Ltd., and the financing company will be the Iron Ore Company of Canada. American companies interested are Republic Steel Corp., Armco Steel Corp., National Steel Corp., Wheeling Steel Corp., Youngstown Sheet and Tube Co., and Hanna Coal and Ore Corp. The work will require construction of 360 miles of railroad, terminal and port facilities, and electrical and power development. Eventual production is estimated at 10,000,000 tons of iron ore a year and the project will cost from $150,000,000 to $200,000,000.

A new ore area in Chile is expected to produce about 1,000,000 tons of ore a year at the end of three years. Development of the El Pao Iron Mountain by the Bethlehem Steel Corp. in Venezuela will be completed in about six months. This area has been under development since 1941 and has cost an estimated $50,000,000. Iron content of this mountain is estimated as high as 72 per cent. Other exploration is also taking place in Venezuela and the country may soon become an important source of ore. Reserves have been estimated at 300,000,000 tons.

Dominican Republic reports that rich deposits of iron ore with 67 per cent iron content have been found in the northeastern part of the country. Deposits are estimated at 43,000,000 tons of ore. The Republic would like to establish a domestic steel industry in cooperation with private interests.

The weight loss of dimer acid oil at 465 F is less than with palm oil as is illustrated by the graph.



Another development during the year was Republic Steel Corp.'s purchase of an interest in the Liberia Mining Co., Ltd. This company has an ore concession 45 miles northeast of Monrovia, Liberia, West Africa. The ore consists of an extensive deposit of high grade hematite and magnetite mixture which assays about 68 per cent and is low in phosphorus, sulphur and silica. It is estimated that reserves of high grade iron ore amount to 5,000,000 tons and there may be an additional 9,000,000 tons of probable ore. Milling grade ore reserves run between 75,000,000 and 150,000,000 tons of 42 per cent iron. A 40-mile railroad which is under construction must be completed. The ore can be obtained through open pit mining, and will be of value as an open hearth lump ore.

One instrument which will help discover future ore bodies is the air-borne magnetometer which cuts down initial exploration costs and reduces time very appreciably.

Use of sinter has increased and about 20,000,000 tons capacity are now in operation. The United States Steel Corp. authorized construction of five sintering plants during the year which will be used to recover flue dust and for the use of iron ore fines. Capacity of these five units will be 1,800,000 net tons a year.

It has been suggested in Congress that subsidies be made to ore producers to finance construction of beneficiation plants for the processing of taconite.

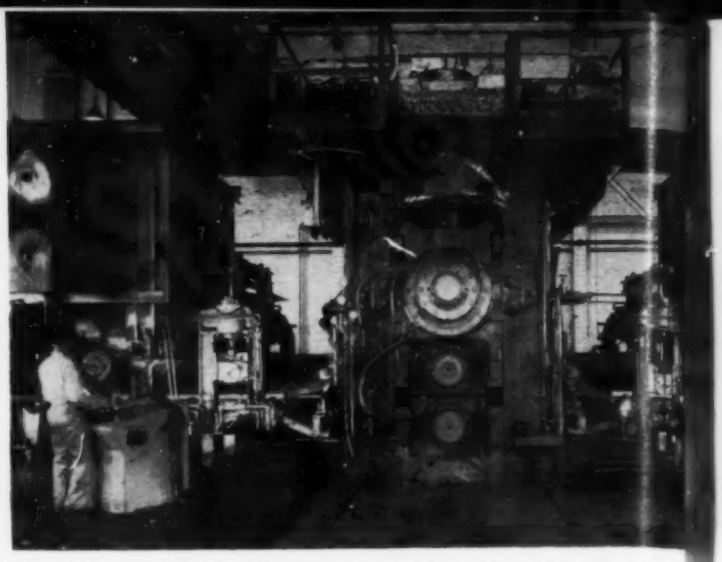
Latest announcements on such processing plants on the Mesabi Range indicate that two plants are being planned which in their final form will have an annual capacity of 20,000,000 tons of high grade ore per year. Since investment cost is estimated at $15.00 a ton, a total investment of $300,000,000 is necessary. Operating costs of the new plants are not known but it is believed that although the cost of the concentrate will be greater than present open pit ore costs, they may not be too far out of line with ore coming from underground mines or from foreign sources.

An example of the problems involved in processing taconite was brought to the fore by the application of the Erie Mining Co. for the water required in their beneficiation process. The project requires a reservoir from which 12,000 gpm water can be pumped to the concentrating plant.

One method which has been proposed for reducing taconite is briefly as follows: Grind the taconite to a moderate size (-40 to -60 mesh) and mix with ground coke or coal for complete reduction. The mixture is then pressed into a briquette and heated. It is claimed that the resulting production will be a friable lump consisting of quartz and spherical globules of metallic iron. At a temperature of about 2500 F, time required for reduction is only a few hours.

Experimentation took place and continued throughout the year on pelletizing. In one method, iron ore powder and crushed coal are mixed and introduced into carbonizers. The combined ore and carbon particles come out as pellets which run from ½ to 6 in. in diameter. The gas and tar from the coal are salvaged and experiments of this type were being carried out by the Pittsburgh Consolidated Coal Co. Other plants are trying other possibilities for the formation of pellets, but as yet few announcements have been received on their results.

The so-called Minnesota pelletizing method requires about 50 per cent of -325 mesh material as a feed in order to obtain hard compact pellets which will not break up when they are charged to the blast furnace. Pickands Mather and Co. recently completed a plant which is designed to produce 200,000 tons annually of pelletized concentrate from magnetic taconite.



This 66-in., 4-high, hot reversing mill is the only one of its kind in the United States. The overhead reheating furnaces on each side are fired at temperatures of 1200 to 2100 F.

At one southern plant two machines have been installed to make briquettes. In a recent report on the operations of these machines, the combined capacity has been about 60 tons of briquettes an hour. Operating the machines 21 turns per week, it has been possible to make the briquettes for a processing cost of about 50¢ per gross ton. Of this amount, the cement cost (used as a binder) is about 20¢, and electric power is about 1¢ a ton. The company believes that this is a very satisfactory process. The briquettes cannot be stocked, as handling and rainy weather cause them to disintegrate. However, operating results show that whereas average flue dust per gross ton of pig iron in 1943 was 117 lb per ton, this figure dropped to 54 lb per ton after the briquettes were adopted.

One recent discovery indicates that when filter coke (de-watered fine concentrate) is fed into a rotating drum with about 2 per cent fine anthracite, the mixture will roll into small spheres that grow like marbles and come out fairly strong. They are then taken to the top of a shaft furnace, through which they settle counter to an air current which burns the anthracite and also bakes the balls into hard porous marbles.

The Ontario, Canada Research Foundation carried out a very extensive study in 1949 on the various types of sponge iron processes. Based on this study, they came to the conclusion that there are three commercially proven methods, all of which have been in production at least five years. The remaining processes, which include 150 other methods, were discarded from their studies, since apparently none of them showed sufficient promise to warrant development expense. The three methods, which are considered feasible are so in only unusual locations where a very cheap reducing agent, such as natural gas, or cheap electric power is available. Another situation which may warrant the use of a direct reduction method is when the required investment for a normal plant is not available and where the sponge iron required is less than 100,000 tons

a year. The processes considered feasible are the Krupp-Renn, the brick kiln process, and the Wiberg-Soderfors process. The first process has been described fairly often and is in use in a number of installations. The brick kiln process is operated at only one plant, the Hoganas Co. in Sweden. In this process fine ore is packed in containers with fine coal or coke and heated to 2000 F. A tunnel type kiln is used and the process should be considered only when existing brick kilns are available.

The Wiberg-Soderfors process is in operation at one plant at Soderfors, Sweden, and the conclusion of the research foundation was that this was the most practical process for Canada. In this process, lump ore, sinter, or pelletized ore is reduced in a shaft furnace. A very reliable method of temperature control is required. A carburetor is used to produce the reducing gases and the necessary heat for the reaction is provided by electrical power. The furnace uses 1000 kwhr, 550 lb carbon and 9.4 lb of electrodes per ton of iron. The study was made in order to determine whether such furnaces would be practical for the reduction of the ore which is obtained at Steep Rock, Ontario. Estimated production cost at Steep Rock indicates that the sponge iron could be made at $29.00 a ton based on costs in South Ontario in 1948.

Advantages of the Wiberg-Soderfors process are that ores of different types can be used (after sintering or pelletizing), sulphur is effectively removed, fuels of different kinds can be used and fuel consumption is low. The sponge iron which is obtained is suitable for melting in arc furnaces. Several plants are under consideration and under construction at the present time.

The Germans have been experimenting on the use of non-coking quality coal for the production of pig iron, and a company has been formed to discover whether the procedure is practical on a production basis. In the process, the iron is mixed with coal briquettes which are then subjected to low temperature carbonization and the mixture is then melted in a low stack furnace. If the process proves practical, this means pig iron could be produced without requiring coke plant or blast furnace.

In a new shaft type electric blast furnace, plant run-of-mine ore is handled from the pile, through a grizzly, then through a rotary drier and then through a hammer and rod mill from which it runs by conveyor to storage bins. The ore, lime and coal are then fed to the collector head and to a rotating distributor. The furnace, which is 37 ft high, has an inside diameter of 7 ft. The hearth is electrically heated by three 500-kw single phase transformers through three 8-in. graphite electrodes which are set down close to the hearth. The blast is discharged through two tuyeres. A black-band ore is used and since this is carbonaceous it needs no additional coal. The iron oxide falling freely down the shaft of the furnace, is reduced by carbon monoxide gas formed at the hearth. Since the reduction produces heat, no additional heat need be supplied for the reaction. The sponge iron which drops to the hearth is melted by the heat from the electrodes. The silicon is reduced by the excess carbon and heat at the hearth. The ore used has an iron content of 22-30 per cent and contains from 10-25 per cent SiO_2. It is estimated that such an electric shaft furnace of 250-ton capacity can be built for about $500,000.

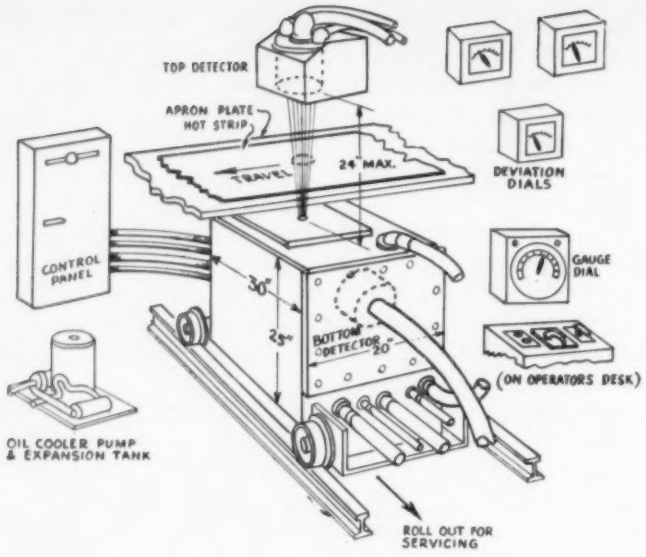
Work continued during the year on the use of oxygenated blast for the blast furnace. No results on this work were announced and whether the results have been beneficial is still unknown. It is doubtful that enrichment beyond 30 per cent oxygen would be feasible.

High top pressure blast furnace operation is finding increased acceptance and this is true also in Europe. In Great Britain, one of the older type blast furnaces is being converted to top pressure operation and this change is expected to increase output from 3500 to 4000 tons per week.

A report on Russian operations told how steam has been used in the blast. This steam helps to cause a reduction reaction since in contact with carbon it breaks down to hydrogen and carbon dioxide, and the hydrogen in turn combines with the oxygen in the ore. About 5 per cent steam is added to the blast and some additional heating of the blast is used to compensate for the heat loss in decomposing the steam. In a 23-day test program, steam was added to the blast at rates varying from 1½ to 4 tons per hour and the blast temperature was 1350 to 1450 F. The average daily tonnage increased from 1135 with ordinary operation to 1455 with the steam operation. It is reported that the furnace runs more easily and coke consumption per ton of iron is decreased. This latter report is contrary to experience reported by American operators during the war. In the operation, the amount of steam is limited by the allowable blast temperature, and for blast temperature of 1800 F, 6 per cent H_2O is the maximum which can be used.

In a paper given during the year, one operator states that a comparison of large and small blast furnace units shows that the production rate per unit of hearth area in a large furnace will approach that of a small furnace when high grade raw materials are available. However, as raw material quality deteriorates, the small furnaces will maintain a proportionately higher production rate than the larger furnaces. The coke rates of the large and small furnaces remain comparable, but the larger furnaces, however, require greater care and handling in their operation.

Carbon has been used as a refractory lining for blast furnaces on a number of installations, in the hope that carbon refractories would reduce blast furnace down-time because of their load carrying capacity at elevated temperatures, and their relative immunity to attack by gases and slag under reducing conditions. These refractories have shown many advantages. However, there have been some weaknesses which have slowed up their more extensive use. Because of this fact, a comprehensive research program is being planned at the Mellon Institute which will investigate the grades of carbon found in the United States, Germany and England, which may be suitable for blast furnace linings. The investigation will develop physical data and properties of carbon, such as chemical composition, porosity, specific gravities, densities, expansion characteristics, volume stability, gas permeability, thermal conductivity, modulus of elasticity at 2500 F, mechanical strength at ordinary and high temperatures, and reaction with gases and titania.



X-ray thickness gages for hot strip mills help increase speed and production of such mills.

At least one carbon lining now being installed follows the idea of British practice. This lining is made of carefully machined blocks which have been keyed in place, thus enabling the space between the blocks to be greatly reduced.

Some blast furnace operators believe that a sillimanite ramming mix installed in a monolithic pad at the bottom of the furnace will give operating results which are just as good as those produced when carbon hearths are used. In the preferred construction, a layer of sillimanite from 9 to 13½ in. thick is placed about two courses of bottom blocks below the top surface of the hearth and extending out to the hearth jacket. This pad is burned into a dense refractory layer which inhibits the formation of a large salamander. A number of such furnaces in operation have had campaigns which run from 1,000,000 to 2,500,000 tons. The first one installed was taken out of blast after a campaign of 2,500,000 tons and had a salamander of only 780 tons. The cost of such pads is about $2500 more per furnace. Sillimanite ramming mix has also been suggested as a substitute for the carbon paste which is used between the hearth staves and the carbon blocks.

It has been found that, for best resistance to carbon disintegration, the refractory brick must be fired under very high temperatures so that all of the iron oxide content of the brick is chemically combined as a silicate. Such high-fired blast furnace brick costs more than the regular fire clay refractories but it is believed that lower overall blast furnace refractory costs will result from their use. Most common usage is through the stack section above the mantle.

In a procedure developed at the Gary Works, disintegration tests on blast furnace lining brick can be made quickly and effectively. In the test, brick specimens are exposed in a test chamber which is heated to 950 F and then carbon monoxide is introduced at a rate of 20 cu ft per hour for about 40 hours. Forty hours of this type of test are more effective than 120 hours with previous equipment.

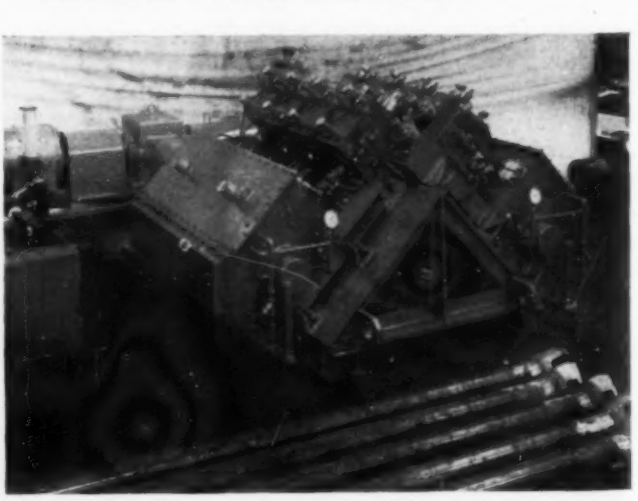
STEELMAKING

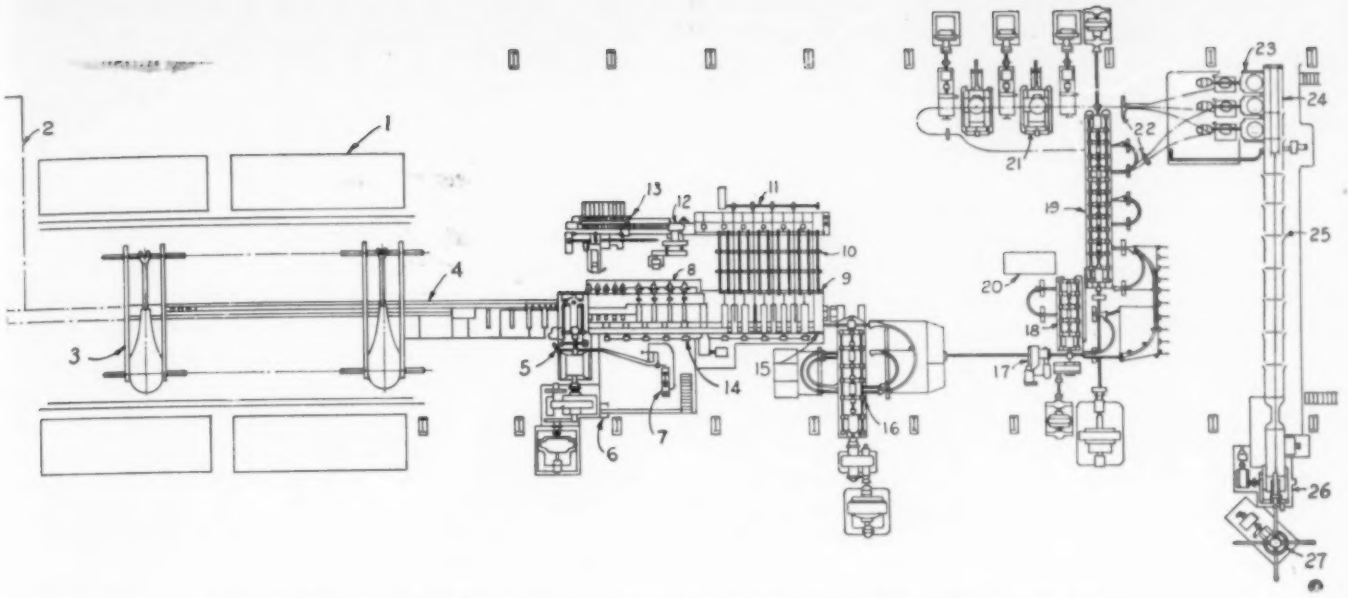
In making the 77,860,943 tons of steel which were produced during 1949, the industry operated at both the highest and lowest rates for which records have been kept. Production in 1950 is starting out at a high rate, as most companies have backlogs remaining from the steel strike. Although steel was produced at a very high rate during the year with the exception of the strike period, electric furnace steel demand dropped off so much that it lost the position it had reached in 1948 as the second largest producer of steel. Open hearth capacity was operated at a rate better than 82 per cent during the year, bessemer steel at better than 75 per cent, whereas electric furnace capacity operated at about an average of 60 per cent, and dropped as low as 33 per cent in July. Open hearth capacity was rated at 84,817,040 net tons, bessemer at 5,191,000 net tons, and electric furnace capacity was 6,112,890 net tons for a total of 96,120,930 net tons at the beginning of the year. Operations for the year including the strike period were about 81 per cent of capacity.

A new steel-making process announced during the year, called the turbo-hearth process, and said to combine the advantages of the open hearth and bessemer processes, is essentially a basic, side-blown converter. As in the conventional bessemer process, heat is supplied by the chemical action of the blown air with the carbon and other elements in the charge, but in the turbo-hearth, the air current is applied from the side of the vessel onto the hot slag and iron of the charge, rather than from the vessel's bottom through the entire charge. The action is fast but is subject to controls which reduce the nitrogen and phosphorus contents, and thus results in a steel which is comparable with open hearth grades. The turbo-hearth is a partially closed vessel lined with magnesia so that basic fluxes may be used to promote elimination of phosphorus. There is also more complete combustion of the carbon in the pig iron, eliminating the usual requirement of the bessemer converter for high silicon iron and allowing the use of ordinary basic pig iron.

The world's largest open hearth furnaces were put

This tube mill is designed for stretch type reducing and has 8 stands driven by a single motor.





An entirely new rod mill arrangement was adopted for the stainless mill at Rustless.

into service in 1949 by Weirton Steel and Great Lakes Steel Companies. Rated at 550 tons, the Weirton unit employs a cold rammed hearth. Only 57 hours were needed to put in the bottom which was made of special granular magnesia refractory. About 178 tons of magnesia refractory were used on the furnace to form a layer 13 in. thick on the bottom at the tap hole and 15 in. thick on the ends. The refractory was mixed with water in concrete mixers and carried into the furnace by a bulk conveyor. Pneumatic hammers were used for ramming the bottom. Railroad ties were then fired to dry out the furnace and two days after that, oil burners were lighted to heat the bottom to about 2950 F.

Experience with the use of oxygen in the open hearth continued during the year, but conclusions on its overall efficiency vary widely. It is still used both for obtaining higher temperatures and for decarburization of the bath, but several shops have abandoned its use for combustion of fuel. Care must be exercised when oxygen is used for combustion in order not to harm the roofs. Some operators recommend that silica roofs be seasoned with at least thirty heats before oxygen is used for combustion.

The use of oxygen for increasing the rate of scrap melt-down as well as decarburization of the steel bath is being found advantageous in the foundry industry.

Operational experience from the first open hearth (a 70-ton unit) without buckstays reports a production averaging 8 tons per hr on an all cold charge after making 300 heats. The door of this furnace is 21 ft wide, and a truss holds the roof channel and supports the suspended roof. The unit is located near Osaki, Japan.

There is a continued trend towards basic ends in open hearth furnaces. Seven more such furnaces were added in 1949 to the twenty-six already in service. Ten more are scheduled. As a result additional data became available during the year. At one plant where a furnace is now on its sixth campaign, tonnages running 60,000 to 87,000 tons were produced, and these were 6.4 to 16.5 per cent above the average tonnages with silica roofs. The cost sheet on these campaigns showed the following changes: increase in roof costs of 0.126–0.373, in fuel of 0.080–0.214, decreases in front and back wall cost of 0.0–0.030, in fluxes of 0.006–0.009, in fixed costs of 0.165–0.264. The composite result is a net change ranging from a decrease of 0.005 per ton to an increase of 0.215 per ton with increases appearing in four of the five campaigns. In the sixth campaign, the use of oxygen points the ability of the basic roof to withstand higher fuel rates.

Another operator with an all-basic furnace which had produced over 1350 heats at the time of the report stated that this furnace was operated under ordinary shop conditions except that the firing rate was 30 per cent above shop average. His conclusions are that qualities and methods of construction of the basic furnace must be improved for it to be competitive with silica brick. Production runs 13 per cent over the shop average, but fuel consumption is about 7 per cent higher because of the increased firing rate and greater heat losses through the brick. His overall economy showed a loss of about 2 per cent.

One factor in the use of basic ends has been the development of a hanger socket for the supported brick. This results in a greater usable thickness of refractory, a stronger brick design, and the casting is kept in a cooler position than the conventional type. Another helpful factor in the use of the all basic ends is the use of a steel-clad brick which gives longer life.

In a paper read during the year, several operators stated that a period of 48 hours should be used to heat up the open hearth furnace after a shutdown for a new roof. Such heating will help roof life.

The Hanna Furnace Corp. has put into production a continuous fusion operation which can use iron bearing metals of any degree of fineness for the production of charge and feed ore of the size and densities specified by the open hearth operator. The pilot plant has processed more than 1000 tons of various grades of iron bearing metals, and the results indicate that conversion costs are apparently the same as the downdraft sintering process. A rotary kiln is used in which the ore and

coke breeze are fed onto a belt conveyor. Mixing takes place in a pug mill and the material then passes to the rotary kiln. When the charge is within a few feet of the discharge end of the kiln, air at 1300 F is directed at the charge under enough pressure to agitate the full depth of the bed. At this time, the ore fuses while the combustion products go up into the kiln to preheat the ore and fuel mixture coming down the kiln.

Production at the new steel making plant at the National Tube Co. of Lorain is based on operating three 25-ton bessemer converters and maintaining one spare 25-ton unit. Most of the steel made in these converters will be deoxidized by a new process which makes it equal to open hearth steel for tubing uses.

Some operators claim that improvements in the design of electric furnaces, as well as the higher cost of raw material for the open hearth, make the electric furnace a competitor of the open hearth for the production of tonnage alloy and carbon steels. The factors which improve the operation of the electric furnace are the swing roof, large furnace volumes, high voltage and power, as well as fast melting single slag electric furnace practice. On the other hand, the higher cost of coal, coke, and fuel oil tend to put the open hearth at a disadvantage. The use of high power input results in extremely fast heat time for melting low carbon steels. In one case a producer taps a 41-ton heat in one hr and 20 min. This operator reports that quality improves with faster melting.

As another example, a 60-ton top charged furnace whose electrical equipment operates up to 400 volts at 30,000 amp per phase, can melt heats at an average time of 3 hr tap-to-tap, which means a production of 20 tons per hr. This compares with the 20 tons per hr of a 240-ton open hearth. It has been estimated that open hearth grades of steels can be produced at a cost of less than 500 kwhr per ton of ingots, and if large enough electrodes are used the consumption per electrode tons of ingots should be under 10 lb.

One of the reasons that the electric furnace may make competition for the open hearth is that the thermal efficiency in some units is up to 80 per cent and steel can be made for about 1,600,000 Btu per ton, which is about half of typical open hearth practice on a 60 per cent scrap and 40 per cent hot metal charge.

Rotary Electric Steel Co. in Detroit finished its expansion program with the installation last March of a fifth 60-ton electric melting unit. At this plant, fast melting rates are also being obtained because of the favorable power situation and the high grade electric furnace scrap which are available. This company has turned out heats of 70 tons of deep drawing steel in less than six hours with the top charge furnaces.

Allegheny Ludlum Steel Corp. started operations last July on a new large top charge electric melting furnace. This is a 70-ton unit, and is one of a four-furnace department which is to include two 70-ton units and two 60-ton units. The two 70-ton units were in operation at the end of the year. The shells of these furnaces are 18 ft in diameter and each 70-ton furnace is equipped with a 16,000 kva transformer. The two 60-ton units are also top charge units, 17 ft in diameter, and have 11,500 kva transformers.

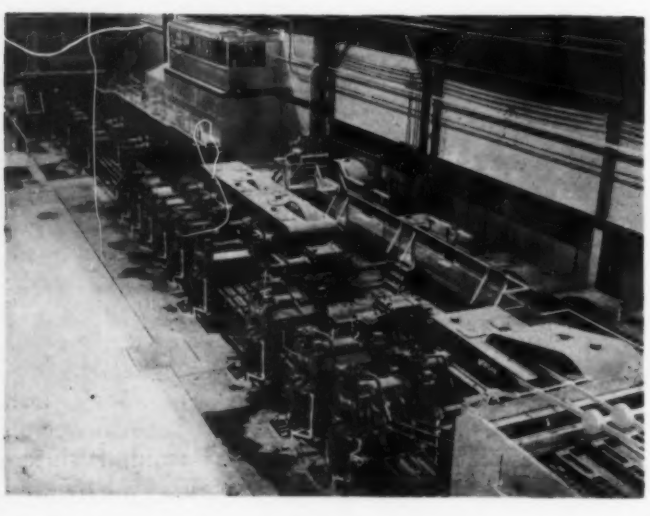
A new low carbon (0.03 per cent maximum) stainless steel has been developed for commercial production during the year, and it is claimed that this new steel has a resistance to intergrannular corrosion equal to that of the stabilized 18-8 stainless steel. These steels can be welded when short heating times are involved.

Additional work continued during the year on the electric ingot process which is a continuous melting and casting process whose operational characteristics make it ideal for producing special complex alloys which must be sound, uniform and free of segregation. This process has been used for making forging blanks 9 in. in diameter and 20 in. long, and the latest machine, a 6-mold model, can produce 1000 lb of ingot metal per hour. A conclusion based on the operation is that the first impression of excess virgin element consumption is a misconception, and is false when the consumption is based on the weight of virgin elements used per unit weight of finished parts. A second conclusion is that the higher the alloy content, and the more difficult the material is to work, the more advantageous is the process. On the other hand two disadvantages inherent in the process are the greater cost of raw materials and the fact that scrap metal cannot be used.

A process for obtaining fine grained high quality steel is having additional capacity installed in both France and India. The steel is produced by first melting, slagging off, adding the required alloy elements and pouring the product into a ladle which contains about $\frac{1}{10}$ its weight of a specially formulated slag. When the temperatures are correct, adequate refining occurs in the few minutes which are necessary to move the receiving ladle to the teeming platform. The final production is low in sulphur, oxygen and inclusions. One of the advantages of the process is that the final results will be the same regardless of what type of furnace is used for the melting, whether acid or basic converter, open hearth or electric furnace, provided that the phosphorus, nitrogen, hydrogen content of the metal tapped from the melting furnace is the same. The slag is melted in the electric furnace and this is a comparatively small furnace. The final result is production of steel from open hearth metal which is fully equal to if not better in quality than the best electric furnace practice.

The most effective means for bringing molten metal

The roughing train and intermediate stands of the new Colorado Fuel and Iron rod mill proceed in line from the exit of the holding furnace which is seen in the lower right hand corner.



and desulphurizer in contact on a commercial scale is said to be a reladling operation. Under controlled conditions, with molten sodium hydroxide as a desulphurizer, 90 to 95 per cent of the sulphur is removed. In the method the molten iron is tapped into an open top conventional ladle. As the tapping goes on, solid sodium hydroxide is added at intervals during the tap, this then melts to form the desulphurizing slag accompanied by a fairly violent reaction which causes foaming. Some desulphurizing takes place in the ladle but the main objective of this part of the process is to melt the sodium hydroxide. After the full metal charge has been put in the ladle, the contents are poured into a second ladle at such a rate as to cascade the metal and desulphurizer into the second ladle, giving effective mixing and a high degree of sulphur elimination.

The use of sillimanite as a refractory on hot metal mixers has been found to more than pay for itself. Although the cost of the refractory is six times more than the cost of high heat firebrick, it was found to give a life double that obtained with the record campaign of high heat firebrick. The resultant net cost is thus 20 per cent lower than the best campaign with firebrick.

A test on carbon and graphite inserts with big-end-down molds in one steel plant showed that the graphite inserts cast into iron stools gave better service life than those that were insulated or fitted into the stool cavity, and the increase in service life was as high as 86 per cent of the life of the standard iron stool. Stool stickers were practically eliminated. There was no effect on steel quality, and the tests indicated that rimmed steel was less erosive on the inserts than either the semi-killed or killed steels.

The Metals Research Laboratory at Carnegie Institute of Technology has been using radio active isotopes for metallurgical research for the last three years, and they have been found very useful in studying the reactions between molten irons and slags. One of the problems which has had to be overcome during the investigation has been the development of the proper type of equipment and procedures for using the isotopes.

A new power source for spectrographic equipment has gone into service during the year. Some of the outstanding features are that it is contained in a small packaged unit, an air interrupter eliminates line voltage control with its high monthly cost, the unit can be used for all emission spectrochemical analyses, and finally an oscillograph close to the operator enables observations of excitation conditions.

The time required for making carbon and sulphur determinations in iron and steel has been reduced from about 10 minutes, the normal time, to 2½ minutes by a method in which the sample is heated by high frequency induction heating to temperatures over 3000 F. A tin-fusion technique for obtaining rapid and accurate analyses of hydrogen in steel will give hydrogen content in about fifteen minutes. In the method a steel sample is melted in the presence of tin and the gases are drawn off under high vacuum. The hydrogen is converted to water vapor which is then frozen out.

A new process known as cathodic vacuum etching has been developed which enables much better observation of flow lines in making microscopic examinations. The true microstructure of the metal is also brought out with much greater detail and clarity.

ROLLING

With the pressure off production and with increased attention on economy, there was an acceleration in the abandonment of the old hand rolling mills, and by the end of the year fewer than 90 of these units were active. Some of the units which were discontinued during the year include those at New Castle, Pa., which were operated for the Hudson Motor Car Co., and the Superior Sheet and Steel Division at Canton, Ohio, which had been making refrigerator sheets for Borg-Warner Corp. Empire Steel Co., which has been making sheets for Studebaker Corp., cut back its production, while Chapman-Price Steel plant at Indianapolis, which had been making sheet for the Kaiser-Frazer interests, was sold several times. The Apollo plant of Phoenix-Apollo Steel Co. discontinued production on its hand sheet mills, but temporarily started up again at the end of the steel strike because of renewed demand caused by the strike. About sixteen or seventeen companies own the 80 to 90 still existing hand mills, many of which are lying idle. Some of these will, however, be kept in a standby capacity, because they can better handle the small odd sized orders than the big continuous mills.

The reasons for abandonment of the old hand mills are evident from the following comparative figures. The crew of a hand mill consists of about eleven men compared with eight men required for present day tandem cold reduction mills, and, at the same time, production from the hand mill is about 1.25 tons per hr compared with 50 tons per hr on a tandem mill. Maximum weight and length on hand mill products are about 150 lb and 12 ft respectively, compared with 30,000 lb and 20,000 ft for a new tandem mill. On the other hand, the cost of a new tandem cold reduction mill with auxiliaries will run about $8,000,000, compared with $150,000 for the hand mill.

One factor which has developed during the year because of the slackening of demand for steel has been that reject sheets are finding few buyers, and, as a con-

The template shown in the back of the photograph controls the operation of the lathe and guides the tool so that the correct shape is formed on the roll.

sequence, it is necessary to direct production more carefully to reduce the percentage of rejects.

Results reported during the year on the palm oil substitution research projects, one sponsored by the American Iron and Steel Institute at Armour Research Foundation, and the other by Shell Oil Co. at Battelle Memorial Institute, show that a great deal of progress has been made on developing such a substitute. As a part of the first project, full scale mill tests were made at Jones and Laughlin Steel Corp., on the use of a dimer acid as a palm oil substitute and this test proved that satisfactory tin plate can be made with a 100 per cent free fatty acid if the acid is not too volatile or viscous. The dimerized linoleic (dimer acid) is a fatty acid made from common vegetable oil by heating under pressure in contact with steam. This substitute works fairly well in hot dip tinning, although further work is being done to make the process more economical. Work will also be carried out in the coming year to determine the possibility of discovering substitutes for palm oil to be used in cold rolling.

The work being done at Battelle has been concentrated on mineral base tinning oils. For hot dip tinning, a combination of two oils has been shown by the laboratory work to provide a satisfactory material. This method uses a tinning oil for the initial charge and a second oil is used as a makeup oil. The following advantages have been reported for this work: preaging of oil is unnecessary, consumption is low because of low volatility, there is little smoke or fumes, the oil is stable at surface temperatures, and good tinning results are obtained for longer periods of time at optimum temperatures. A two week test by a tinplate producer was carried out with satisfactory results. The yield was similar to that obtained when using palm oil. Oil consumption was 0.21 lb per base box, based on primes, compared with 0.30 lb per base box for palm oil and the average oil coating weight with the test oil was 0.90 lb per base box. Further full scale tests are planned to evaluate more fully the economic aspects of the new tinning oils, although present indications are that the new oils can be made available on a commercial basis of savings and improved performance. New oils have also been found which can be used as substitutes for palm oil in the grinding and polishing of stainless steel sheets.

A 42-in. four-high, reversing hot strip finishing mill was installed in a Detroit plant which will operate at higher speeds and produce heavier coils than any similar existing mill. Coil size is 20,000 lb and mill speed will be up to 2000 fpm. A 5000-hp, 125/312.5 rpm motor is used for the main drive.

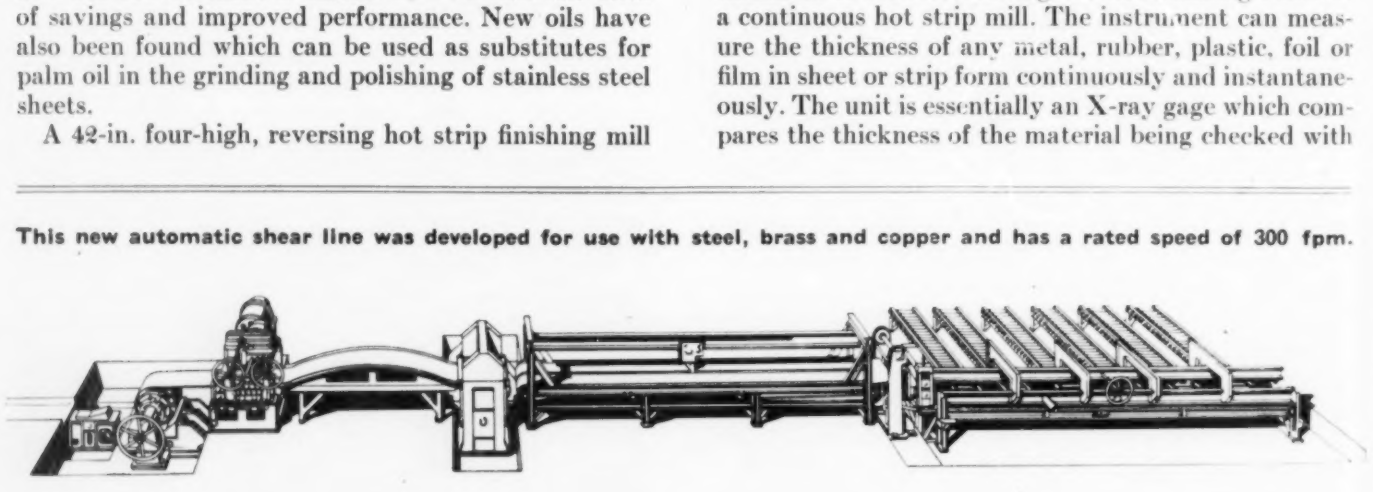
A very unusual reversing mill went into operation during the year at Midland, Pa. This mill is a 66-in. 4-high, reversing mill which uses drum type coilers housed in gas fired furnaces on each side. This mill has rolled strip from one in. to 0.076 in. in thickness, in widths from 15 to 50 in. Further reductions and greater widths will be produced later, and the mill will be ultimately capable of rolling sheet and strip up to 62 in. wide. Operating advantages claimed for the mill are better control and maintenance of gage, better surface, and improved finish on the alloy steels which are a specialty of this plant.

The results of an extensive series of tests on a high speed cold reduction mill were reported during the year. These tests were run at speeds from 3500 to 5000 fpm and graphic charts were obtained for various data. One of the results of this investigation was the conclusion that power consumption in horsepower hours per ton checks closely with results from slower speed mills. Techniques were developed from the tests which reduce the amount of off-gage material. The tests also show that roll pressures decreased during the slowdown period which is contrary to the usual assumption.

Actual plant tests of a unique type of continuously indicating and recording extensometer for measuring the percentage of extension of strip while being rolled in temper pass mills have demonstrated the accuracy of the instrument. This instrument will operate at speeds up to 2000 fpm. The extensometer is electrical and essentially measures the entry and delivery speeds of the strip and compares the differential which is proportional to the extension. In most of the tests, the maximum deviation between the extensometer indication and the measured extension was 0.1 per cent.

At a Cleveland steel plant, gaging equipment was installed which successfully measured continuously the thickness of the steel leaving the last finishing stand of a continuous hot strip mill. The instrument can measure the thickness of any metal, rubber, plastic, foil or film in sheet or strip form continuously and instantaneously. The unit is essentially an X-ray gage which compares the thickness of the material being checked with

This new automatic shear line was developed for use with steel, brass and copper and has a rated speed of 300 fpm.



a sample of the same material which has its dimensions known. The gage then registers deviations from the required thickness. Several similar units have been since installed on other mills.

A new instrument designed during the year, called the recording torque magnetometer, can tell in a matter of a few minutes whether or not any given type steel can be drawn into deep shapes. A flat disc about the size of a 25¢ piece is used as a sample.

The Central Iron and Steel Co. at Harrisburg, Pa. practically doubled its plate capacity by adding a blooming and slabbing mill, soaking pits, continuous slab heating furnaces, etc. The new plate capacity of the plant is 540,000 tons a year.

Work continued during the year on expansion of pipe making facilities at a number of locations, reflecting demand for this product which is still strong. One of the largest projects for this production was essentially completed during the year at the National Tube Co. plant at Lorain, Ohio. This plant includes the first continuous seamless pipe mill ever built, and the mill also uses the principle of stretch reduction. The maximum delivery speed is 1300 fpm, and some of the smaller sizes of pipe are as long as 140 ft as they come off the mill.

In another pipe mill built during the year, hydraulic press-forming and submerged arc welding can be accomplished on one mill. This particular mill can make pipe in sizes from 8⅝ up to 30 in. outside diameter or larger, in thicknesses from ¼ to ½ in. or heavier, with one set of hydraulic press dies. Initial investment in the equipment is claimed to be from ⅓ to ⅙ less than that of conventional equipment.

Increased rolling speeds were attained on Fretz-Moon mills and one unit which went into operation during the year is capable of making pipe in diameters from ½ to 1½ in. at speeds up to 1000 fpm. One of the unusual features of the mill is a flying saw which will cut the finished pipe into lengths from 18 to 54 ft with an accuracy of ½ in. The forming and welding stands are driven by 12 totally enclosed, fan cooled, d-c motors, and the synchronized drive equipment had to be developed for the stands.

A new rod mill which was put in operation during the year for the rolling of stainless steels featured many design advances. The installation has a 5-stand, 10-in. continuous finishing mill with 3 horizontal and 2 vertical stands. This mill finishes at speeds up to 2800 fpm, which is double the maximum finishing speed for hand looping mills rolling stainless or alloys. One of the features of the 18-in. roughing mill is the cap which is secured to the housing posts by 4 heavy shear pins instead of the usual cap bolts. Wedges are used to take up the pin clearances, and this feature eliminates the mill stretch and gives the rigidity of solid housing. The mill rolls 4 x 4 in. billets to No. 5 rod in 260 lb coils with a production of 6 tons per hr of No. 5 rod in an 8 hr shift with eleven men. The speed of the mill helps from a metallurgical standpoint, and a 265-lb, 4-in. billet taken from the furnace at 2200 F will have been rolled to a ¼ in. rod in two minutes and 18 seconds while the temperature will have dropped only to 1720 F.

A new $5,000,000 combination rod and billet mill went into operation at the Minnequa Works of the Colorado Fuel and Iron Corp. The mill consists of four breakdown stands after which the material goes through a more or less conventional 23-stand rod mill. The installation included all the auxiliary equipment necessary, such as the heating furnaces, billet handling equipment, holding furnace and rod mill proper. The mill will produce 700-lb bundles as compared with 165-lb bundles previously. The capacity will be about 200,000 tons of coiled rod annually.

The continuous heating furnace which is rated at 60 tons per hour is of the side-charge, side-discharge design with a level hearth 69 ft 8½ in. x 26 ft wide. It is built for top firing with coke oven gas in a two-zone arrangement. The suspended roof forms a knuckle between the soaking and heating zones and another towards the end of the heating zone. The hearth skids are of the dry type consisting of rolled steel in the first 40 ft and of silicon carbide refractory through the next 11½ ft. In the 15 ft 8 in. soaking zone, the hearth is built of plastic chrome ore rammed in place and sintered at 2600 F. The furnace has automatic temperature control, and the temperature of the coke oven gas which fires the furnaces is also controlled automatically as is the furnace pressure.

The breakdown roll train which follows the furnace consists of four 18 in. stands in which the 4⅜ in. billets are reduced to about 2½ in. squares. The holding furnace which follows next is a side-charge, side-discharge unit with a hearth 37 ft wide x 6 ft long. In the rod mill proper, the continuous roughing train consists of 9 stands which is followed by a cropping shear, then by 5 continuous 13-in. intermediate stands. These are then followed by two individual intermediate stands and finally by a 7-stand finishing train. Product ⅜ in. in diameter and larger leave the mill at stand No. 15 at speeds up to 1600 fpm, and passes to either of two pouring reels. Product under this size leaves stand No. 22 at speeds up to 5000 fpm and passes to one of six laying reels. Products in this size range may be rolled three strands at a time.

A new 10-in., continuous, double-strand, high speed combination rod and merchant bar mill was installed at the Los Angeles plant of the Bethlehem Pacific Coast Steel Corp. This mill has 21 horizontal stands, driven through 9 adjustable speed motors, and is arranged in a group of nine roughing stands, four intermediate stands, two looping stands, and a six-stand rod finishing train. All merchant sections are finished on No. 14 stand at delivery speeds up to 1500 fpm. Wire rod is produced at rates up to 4000 fpm with double strand rolling off the last finishing stand where it is delivered to four laying type reels.

Equipment has been designed during the year which enables the rod mill operator to continuously draw, straighten, cut to length and polish both ferrous and non-ferrous stock direct from the coil. One-inch rod can be handled at a rate of 150 fpm, and ¾-in. rod can be handled at speeds up to 200 fpm. This line is continuous and the component pieces are interlocked, both mechanically and electrically, with the result that the automatic operation gives twice the production of the conventional draw bench and three times that of the continuous draw bench.

One of the outstanding developments during the year in wire drawing equipment were the installations put

Two continuous galvanizing lines are located in this Pittsburgh district plant. The one on the left is used for the heavier gages.

into operation during the year for processing stainless and alloy grades of steel. American Steel and Wire Co. put into operation its new line at Waukegan, Ill., for the production of stainless steel wire. This mill has a capacity of 6000 tons a year. One of the unique features of this mill is that the 175-lb coils of rod are welded together on a flash welder into 500-lb bundles, an operation which is new in the stainless wire industry. The wire is annealed in two new rotary hearth furnaces and a small batch furnace. All the wire shipped from this plant is bright annealed using an atmosphere of hydrogen and nitrogen.

A producer of specialty steels has found it advantageous to hot draw the specialty items which are difficult to cold draw. The hot draw equipment consists of payoff reel, a gas-fired lead bath followed by a graphite spray which gives automatic lubrication, and this is then followed by the drawing die. Drawing speeds run from 150 to 300 fpm. The temperature in the bath is about 950 F, although when the wire enters the die it is about 600 to 650 F. The dies are heated to the temperature of the stock. After the initial hot drawing pass, as many as 8 or 10 subsequent hot drawing passes can be made.

During the year, some operators reported on the use of back pull wire drawing. The machine incorporates the feature that the wire passes directly through the die from the block, the block pull is adjustable to any required torque and remains in constant ratio with the torque of other blocks at all speeds. Any draft from zero per cent up may be used on any block. The operators have found that the temperature with high back pull was 30 F higher than with low back pull. The operators also reported that the draft could be within a range of 30 to 40 per cent without undue breakage.

One of the midwestern steel producers developed a new process for removing secondary scale from flat steel shapes. In the process, disc-center wire wheel brushes, driven by 2-hp motor, are used to grind off the scale as the pieces come through the mill. The pieces that are brushed are run against the direction of the brushes. These units are installed on an 8-in. and 10-in. bar mill and clean the steel at speeds up to 700–1200 fpm. The brushes operate in a water spray, and the steel temperature is a little over 1800 F while it is being cleaned by the brushes.

Submerged arc welding is now being used in a machine developed for the purpose of welding together coils of strip. The splicer will handle strip ranging from 0.06 in. to 0.183 in. in widths up to 56 in. The machine is semi-automatic.

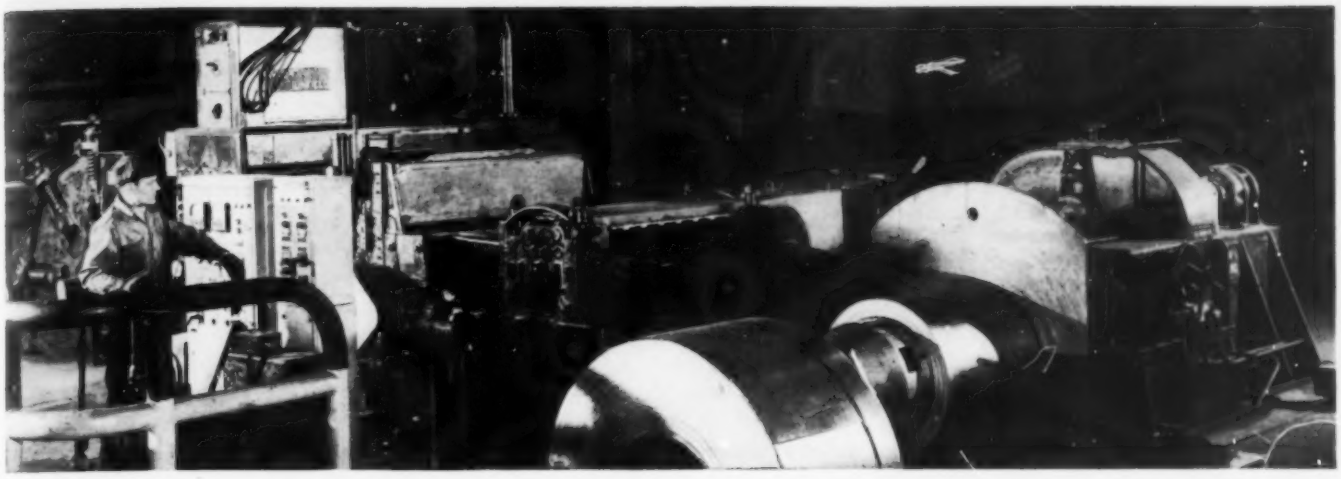
Higher speeds are available on roll turning lathes, and it is possible when using pressed carbide tools to attain cutting speeds as high as 1650 surface fpm with a feed of 0.015 in. per revolution, and depth of cut of $\frac{5}{16}$ in. About 140 cu in. of metal can be removed per minute on 1050 steel. The lathe is rated at 50 hp and has a total loading of 84 hp.

FINISHING

For the first time since the war, the Department of Commerce eliminated controls on the use of tin. One of the results was that metal can shipments for 1949 were 3,225,000 tons (in terms of steel), only slightly under that for 1948, a year of much greater overall steel production. For 1949 electrolytic tin plate production is estimated at 2,000,000 tons compared with 1,800,000 tons of hot dipped tin and terne plate. This reverses the figure for 1948 when 1,800,000 tons of electrolytic tin plate were produced compared with 2,200,000 tons of hot dipped tin and terne plate.

Hot dipped tin plate production procedures have not remained static and many improvements have taken place in the production of this product. One of the developments provides a feeder and pickler immediately ahead and in tandem with the tin machine which can handle lifts of sheared plate which weigh as much as 10,000 lb. Plates are then fed automatically to the tin

These two new continuous pickling lines are used to process strip from a 68-in. mill.



Out of the experimental stage into full production is the new terne-coating line at Gary Sheet and Tin Mill of Carnegie-Illinois Steel Corp. The 260-ft production line is the first of its kind to employ a new electrolytic pickling bath.

pot from the electrolytic pickling unit. Following the tin plating operation, a continuous line is set up in tandem which counts, weighs and packages the product from the tin machine, thus avoiding the manual and tractor handling of the finished product. Inspection is done on inspection wheels, where the inspector can grade the plate and send it to the pilers as prime piler, mender piler, and waste waste.

Inasmuch as electrolytic tin plate is so much thinner than the hot dipped, it is most essential that the coating be applied more uniformly. A new meter has been developed at one plant which continuously indicates and records tin coating thickness on steel strip during the plating operation. This meter is separate from the other control instruments on the line, and it combines the electric values of plating current, strip speed, strip width and plating efficiency in a precision circuit which uses a self-balancing potentiometer to indicate and record the thickness. The instrument is calibrated in lbs per base box.

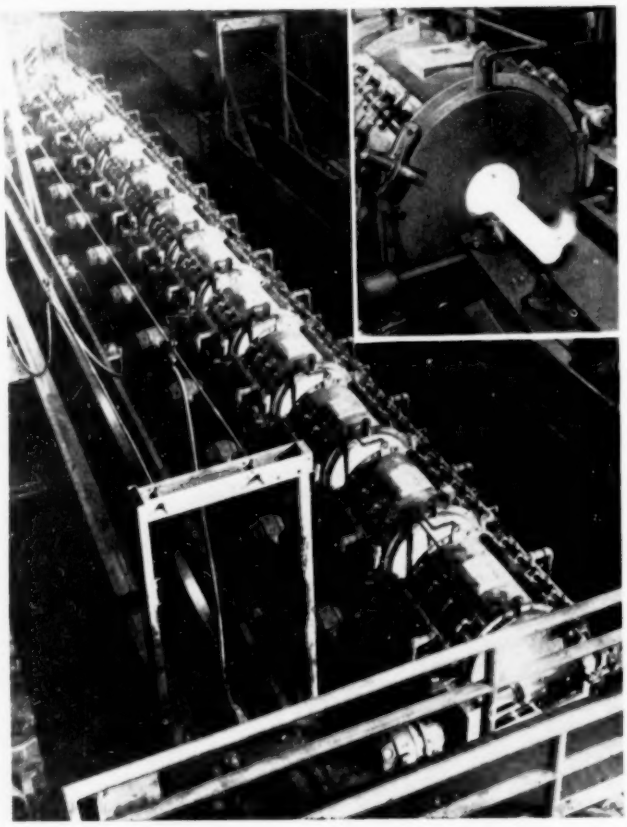
Considerable progress was made during the year on the operation of continuous galvanizing lines and installations are operating in at least five different plants. One of the basic problems which had to be overcome before such units became practical was to synchronize machine roll speeds to compensate for variations in roll diameters. A continuous galvanizing line is composed of about 19 units, many of which are similar to those of the electrolytic lines. Among these are an aqueous flux tank and radiant tube drier. On the entry side, the pot uses a zinc ammonium chloride solution instead of the sal ammonium flux which is commonly used. A vertical spangle tower is used instead of the conventional spangle conveyor. It is understood that the lines have a maximum speed of about 300 fpm, and normally operate at about 180 fpm, thus producing about 10 tons per hr. A continuous galvanizing line in the Pittsburgh district differs from the layout described above in that the annealing is done as an integral part of the line in a controlled atmosphere electric furnace. Production on this line is about 300 tons per 24 hr day of 11-18 gage material and its speed varies from 8 to 120 fpm. The line is equipped to handle coils as heavy as 50,000 lb. A second line is in operation in this plant which produces product running from 19 to 30 gage.

Another continuous galvanizing unit has a maximum speed of 300 fpm and will handle material having a maximum width of 48 in. It will handle coils up to 30,000 lb of 18 gage and lighter. In this unit, the coils pass through an anodic-cathodic electrolytic cleaner at a maximum operating speed of 2000 fpm. The coils are then annealed in coil form, and next, is a special rolling operation to give a flat surface. The coils are then placed in an uncoiler, the little end is fed into a pinch roll, the end is squared, and an electric wheel type spot welder joins the tail end of the passing coil to the lead end of the next coil, after which the material passes through a 50-ft looping pit. The strip then goes through scrubbing units, acid and spray tanks, an aqueous flux bath, and a radiant tube furnace. It then goes into a 100-ton bath of zinc, over a cooler tower and down on a cooling table. The operating speeds of this unit run from 120 to 240 fpm, and it will produce about 4600 tons of light gage material in a 25-day month. Six men are required for the operation.

Another unit which has operated successfully for some time in the Pittsburgh district is one that continuously coats heavy gage strip 12, 16, and 18 gage. This unit combines a pickling of the hot rolled strip coils with the galvanizing operation into one continuous unit. The average operating speed of this line is 50 rpm, and with 16 gage material production averages 10 tons per hour.

One difference between the product produced on the continuous galvanizing line and the hot dipped product is that electrolytic product is essentially pure zinc and does not contain the layer of zinc-iron alloy which is a feature of the hot dip process. The resultant electrolytic product is more ductile and can stand greater forming.

Work continued during the year on finding economical methods to dispose of pickle liquor. One method of treating pickle liquor has been to apply lime slurries which are then dewatered by lagooning. Space is not always available for the lagoons and for plants which are faced with this problem, a method has been developed which uses dry lime for the production of sludges which will quickly settle and which can be dewatered at fairly rapid rates on vacuum filters and centrifuges. The method makes possible the installation and opera-



Thirteen reheating furnaces are used for heating pierced seamless tubes. Electric eyes shown in insert adjust the temperature automatically at each unit.

tion of plants of a minimum size, but the method does increase lime consumption. Therefore, as volume and concentration of the pickle liquor increases, the lime cost finally becomes so high that this disadvantage outweighs the other advantages of the method.

Another method has been developed which reduces the volume of the sludge that settles when pickle liquor is treated with lime by the conventional treatment. In this process the sedimentation is virtually complete in less than an hour, depending on the alkaline agent used, and the filtration rate is much higher than with conventional slurries. The process depends on controlled oxidation of the ferrous hydrate to ferrosoferric oxide.

Ultrasonic waves have been found to be very effective in degreasing. The method is based on the use of a magneto-striction transducer which produces ultrasonic sound waves at 33,000 cycles per sec into the cleaning solution. These waves agitate the molecules of the solution and scrub the steel surface. The method can also be used for descaling steel parts.

One item which may affect plating speeds is the discovery that about 1 per cent aluminum in the tin anodes used in alkaline tin plating will allow a marked increase in the current densities which are obtainable. This work is based on using a potassium stannate type bath. It was also found that an agent can be added to the electrogalvanizing bath which substantially lengthens the bath life. This addition agent enables the bath to be kept at a pH of about 5.8 rather than the usual 4.0. The material also seems to improve the coating.

One steel plant found that the use of air heaters were effective in defogging vapors from pickling jobs by creating a warm air blanket in the area above the acid dipping vats. The condensation rate was then found to be reduced.

A method was patented during the year for bonding aluminum on steel which promises wide usage. In this method, a fine iron coating is deposited on the steel electrolytically as a bonding agent. The process is a continuous one which includes a cleansing electrolytic bath to receive the iron coating, a furnace which heats the coating to 850 F, and then a rolling mill which applies the strips of aluminum foil.

A method was also developed during the year for measuring thicknesses of tin coatings. The procedure is based upon the absorption by the coating of secondary X-rays excited in the base metal by means of an X-ray beam. Units have been built which are now in experimental use.

FUELS AND FURNACES

The higher speed tube mills which have been put into production in the last year have required reheating furnaces with a higher than normal heat input. One unit installed for a final sizing mill consists of 13 furnaces designed to heat tubes with a range of 2⅝ in. outside diameter by 0.120 in. wall thickness up to 9¼ in. outside diameter by 1.75 in. wall. This line operates at temperatures from 2400 to 2600 F, and the scale which is formed during piercing and rough sizing operations flakes quickly as the tube hits the first high gradient chamber. Production capacity is from 10 to 30 tons per hour and the tube moves at speeds from 50 to 160 fpm.

At another tube plant, a five-zone rotary furnace is used to heat the billets for piercing. This unit is rated at 50 tons per hour when heating sections 16 ft long and 8 in. in diameter to 2350 F. The maximum fuel input is 125,000,000 Btu per hr. This furnace is the first unit of its type which incorporates five separate walled or baffled temperature zones with individual stacks from each zone. The furnace can heat billets from 3 to 8 in. diameter and 3½ to 16 ft long. The heat chamber width is 19 ft between walls, and the height is 5 ft 6 in. inside the furnace. The diameter of the steel shell of the inner wall is 19 ft 10½ in., and the diameter of the outer wall is 64 ft 1½ in. The first three zones in the furnace each cover a 90 degree angular sweep, and the final two zones each have 45 degrees. The charging machine is automatic and the discharging machine is manually controlled.

A new furnace scheduled for a skelp mill in the Chicago district is being equipped to handle 35 ft billets and will have a capacity of 80 tons per hr.

A new furnace to anneal stainless clad steel sheets, thus eliminating the undesirable scale which occurs by standard methods, results in a product whose scale has been reduced to such a degree that pickling time is cut in half. This furnace is a radiant tube continuous roller hearth which can be used for continuous operation at temperatures up to 2050 F. Following the furnace unit is an air quench unit which gives the heated metal a rapid cooling below the scaling range.

In a new soaking pit installation in the Pittsburgh district, control has been achieved which keeps tem-

peratures within plus or minus 10 F. This battery of pits is composed of 8 tangentially fired circular soaking pits, 13 ft in diameter and 7 ft from top of the bottom to parting line of the pit. Pits are staggered in two rows of four each, and each furnace can handle 60 to 65 tons of ingots per load. One of the unusual features of the installation is that dry mill scale is used for the bottom instead of coke. This installation shows no signs of fusion and gives bottom life up to 9-10 months with no decarburization, erosion or corrosion. In the pits, carbon alloy and silicon grade ingots are heated up to 2450 F in about 8½ hr from cold temperatures.

A trend in use of refractories is to go to a longer lasting brick. This is due to higher labor rates for bricklaying and to the fact that the number of bricks layed per manhour is substantially reduced. Many bricklayers are also reluctant to make good hot repairs, and thus it becomes worthwhile to use higher quality and perhaps more costly refractories whose longer service will thus give a more economical cost for the long term. An auxiliary result of this trend is a tendency toward the use of special refractories for specific purposes.

In an attempt to reduce refractory costs, one steel plant has gone to the extent of requiring that all its brick be racked on pallets by the shipper, or palletized as unloaded and handled by lift trucks. At this plant all silica brick is oiled to reduce the amount of silica dust.

It is well known that when a fuel is burned with oxygen, such as has been done in the open hearth on an experimental basis for several years, higher temperatures result because of the elimination of the idle nitrogen gas. The operator also has the advantage of wider ignition limits and higher combustion velocity. This recent work has raised the question as to whether it would be worthwhile to use oxygen with industrial gas for various types of furnaces. Preliminary results of this work indicate that it may be economical to use oxygen enrichment for processes already in existence. In one case with 20¢ oxygen, the fuel cost with air is $10.50 an hour, and if 97 per cent oxygen is used, the cost drops to $5.70 an hour. Many practical problems such as burners and refractories must be overcome before the operator goes overboard in switching over to the use of oxygen.

One factor which may affect future fuel developments is the development of low-cost methods for mining oil shale, thus eliminating one of the major deterrents for the utilization of the mammoth reserves in the United States. In test runs made at a mine near Rifle, Colo., about 30,000 tons of oil shale were mined at a direct cost of 32.9¢ per ton. Average production per man day totaled 111 tons for underground labor and 92.7 tons for all labor. New practices in the use of large scale modern equipment are the major factors in the development.

The development of a synthetic fuel industry will, however, be a major undertaking. Some idea of the magnitude can be visualized from the fact it has been estimated that an industry which can produce 1,000,000 bbl of synthetic fuels per day from coal (⅙ of present domestic petroleum production) will require an estimated capital investment of almost $9,000,000,000, 6,400,000 tons of steel, an operating force of 160,000 men and 210,000,000 tons of coal per year.

Cost of producing synthetic liquid fuels has dropped to the point where gasoline, diesel oil and heating oil can be made from coal and oil shale for as little as 8.4 to 12¢ a gal.

The coal hydrogenation plant at Louisiana, Mo., completed a seven weeks test run at the end of the year in

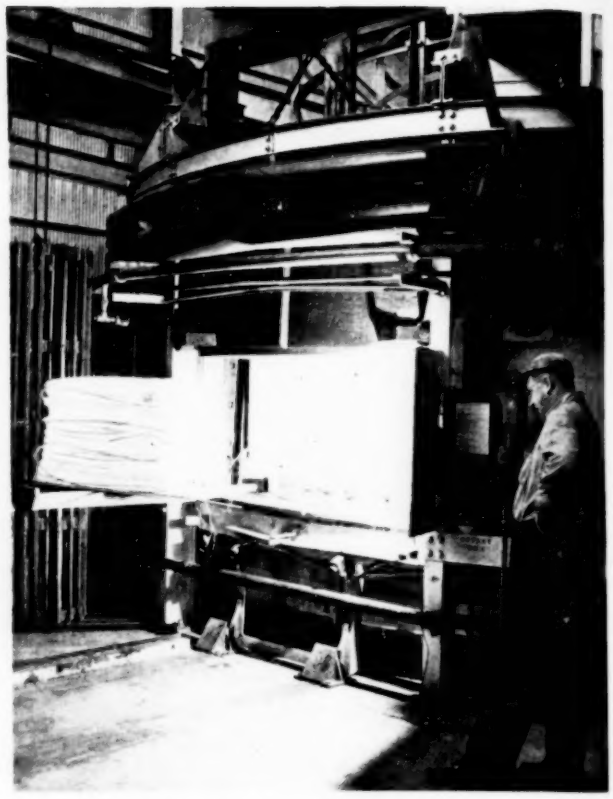
Typical of modern slab heating furnaces is this unit which has a capacity of 330 net tons of slabs per hour for a 68-in. eastern mill.

which it converted coal tar oil and Wyoming coal to gasoline and other fuels. This is the first time that substantial quantities of oil have been made from coal in this country. The test run showed that the basic plant design was sound and operable. Since the primary chemical difference between coal and crude petroleum is that there is approximately two times as much hydrogen in petroleum as there is in coal, the problem in hydrogenation of coal to finished gasoline is to add about 9 per cent of the weight of the coal in the form of hydrogen to form the petroleum products. The Louisiana plant operates at 700 atmospheres and the operation takes place in two major steps. In the liquid-phase hydrogenation, the coal is liquefied, and in the vapor-phase hydrogenation, the liquefied coal is converted to gasoline by-products. Pumps operating at 10,000 psi are used in the process. A catalyst is also required. In the design and construction of this plant, it was found that extremely severe design specifications had to be met in order to provide units which would withstand the service of 10,000 psi.

A new source of fuel becomes available in the hydrocol plant, in Winnie, Texas, which was scheduled for operation late in 1949 and which will produce gasoline from natural gas. In this process natural gas is converted to a mixture of carbon dioxide and hydrogen, which in turn is followed by a catalytic reaction which will produce liquid hydrocarbons substantially within the range of gasoline. The by-products are high grade diesel oil and oxygenated compounds such as alcohol. This plant will process about 64,000,000 cu ft of natural gas per day which will produce 5800 bbl of motor fuel, 1200 bbl of synthetic diesel oil and 150,000 lb of crude alcohol. If diesel oil is credited at 3½¢ per lb, and alcohols at ½¢ per lb, it is estimated that out-of-pocket gasoline costs will run about 2½¢ per gal. Exclusive of capital cost, if interest, depreciation and amortization are added, gasoline costs become 5.25¢ per gal which compares favorably with gas costs from crude oil. One of the big elements in the plant is a unit which will produce 40,000,000 cu ft per day of high purity (95 per cent) oxygen from the air. This went into operation last February. Two of the largest centrifugal compressors ever built are incorporated in this plant and they will compress 110,000 cu ft per minute of air to 100 psi with a power requirement of 23,000 hp for each unit. The oxygen leaves the plant at pressures of 1.5-2.5 psig.

In the coal gasification work underway at Gorgas, Ala., some 500,000 tons of coal have been blocked out in an outcrop area where the maximum overburden exceeds 130 ft. Five large diameter holes have been drilled to serve as air inlets and gas outlets. The three holes which are used for hot gases are fitted with 20 in. carbon pipes which are surrounded by 4 in. of refractory cement. In order to prevent gas leakage through other than the gas outlets, pressure grouting was done with cement. A large number of test readings are being made in this experiment and it will be months before all the data becomes available.

In addition to the coal gasification work at Gorgas, somewhat similar work is being done by the University of Missouri School of Mines and Metallurgy and Sinclair Oil Co. In these tests, electric current controlled by water rheostats, is sent into a 2½ ft seam of coal through electrode pipes. As the coal is heated, it gives off an oil-saturated gas which comes to the ground surface through the same pipes which act as electrodes. The gas product has a high heat value of 500 to 600 Btu and is rich in oil. After the coal has reached a sufficiently high temperature, the electric current is stopped and air is pumped into the seam to sustain further combustion.



One thousand lb of red-hot stainless steel rods are removed from a new rotary furnace. The furnaces, heated to about 2000 F, are controlled electrically and used to heat treat stainless rods, preparing them for drawing into wire.

Additional natural gas fuel will be made available by a pipe line, started during the year, which will run 2250 miles from Texas to New York. When it is completed early in 1951, it will deliver about 340,000,000 cu ft of natural gas a day and eventually will be capable of delivering 500,000,000 cut ft. Estimated construction cost is $190,000,000, and both 30 and 26 in. pipe will be used in the main line.

MATERIALS HANDLING

Perhaps the greatest development in materials handling has been the increased attention given to belt conveyors. The most unusual project, known as Riverlake, would run for 130 miles from Lorain, Ohio, southeast to the Ohio River, and would carry 35,000,000 short tons of iron ore south from Lake Erie and 22,000,000 tons of coal north to the lake. Estimated savings through the use of the conveyor run from 58 to 78¢ a ton. Although the longest belt conveyor built so far has been about 10 miles long, the engineering problems on this conveyor should not provide any insurmountable obstacles. The biggest problems which must be over-

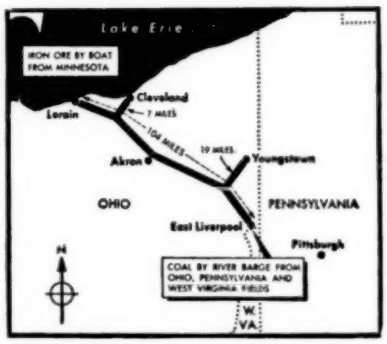
come are legislative, political, financial, and power sources. It is estimated that the unit would cost $210,000,000.

Continuing increased capacities in trucks is a lift truck produced during the year which is designed to lift and carry dies weighing 80,000 lb and which can actually handle loads up to 110,000 lb. The truck weight itself is 40,000 lb, it is 85 in. wide and 184 in. long.

The nation's first gas turbine locomotive went into operation during the year for a commercial railroad. The unit develops 4500 hp and weighs 500,000 lb. A 4000-hp coal burning gas turbine locomotive should be ready for testing in the beginning of 1950. It is expected that fuel and maintenance costs on this unit will be less than for any other built. As an example, fuel costs should be one-half that of the diesel engine. It is estimated that a proposed steam turbine electric unit will use about 6500 lb of coal per hr, while the gas turbine units will use between 4000 and 4500 lb per hr. One of the problems in the design of these units has been the design of an efficient and adequate coal handling system.

A diesel-electric tug boat which is the first of its type on the rivers was put into operation at a coke plant in the Pittsburgh district. This is used as a harbor tug to shift barges supplying coal to the by-product coking plant. The vessel is of all-welded, mild alloy, steel construction.

Materials handling operations are being sped up by the use of radio communication devices. Such devices are used on soaking pit cranes in several plants and are also used on ore bridges and transfer cars. Another plant is using trolley phones on their electric furnace cranes. Still another application provides communication for both the pusher of a coke oven battery and the hot car. Although these units are sometimes called wireless or radio, they generally require a d-c power line at the point where the telephone is desired. A high frequency carrier wave travels through the existing power lines, and other phones can be connected on the same circuit.



The route of the proposed conveyor system for transporting ore to the Pittsburgh area is indicated in this sketch. (Photograph courtesy of Life Magazine.)

The first automatic billet-charging mechanism went into operation this year to feed a rod mill heating furnace. The machine is fully automatic and requires no labor. It is understood that five such units are on order.

MECHANICAL DEVELOPMENTS

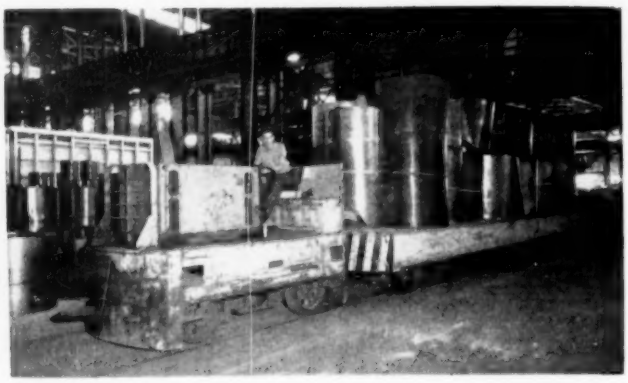
The new power plant which went into operation at Sparrows Point uses steel mill by-product fuels for the production of over 75,000 kw of electrical energy. The station has two 450,000 lb per hr boilers with multiple fuel firing which furnishes steam at 875 psi and 900 F total temperature at the superheater outlet. Two standard hydrogen cooled 30,000 kw turbo-generators are installed.

A power plant went into operation during the year in the midwest, which claims the unusually low heat rate of 9300 Btu per net kwhr with a boiler efficiency of 90 per cent. The boiler in this plant has a capacity of 930,000 lb of steam per hour at a drum operating pressure of 2300 psi and final steam temperature of 1050 F. Included also is a reheater designed to handle 840,000 lb of steam per hr with a final pressure of 385 psi and a temperature of 1000 F. In this case, the reheat cycle will produce a kwhr for 5 per cent less coal than a straight regenerative cycle using the same pressure and temperature. A pioneer step in this boiler design is the method of steam temperature control which is accomplished by recirculating the flue gas taken from the economizer outlet to the furnace combustion zone. As a result, less heat is absorbed by the furnace, and more heat remains available for absorption by the superheater and reheater.

In the last two years reheat units have not been as popular as in the preceding decade, because the development of new materials enabled the designer to increase his efficiency, thus raising temperature and pressure. However, because of present limitations in materials, reheat units are becoming more popular again.

Austenitic steels were incorporated in the high steam temperature regions. This jumped the cost of this particular plant, but inasmuch as there is a gain of efficiency of about one per cent for each 10 F rise in steam temperature, it is felt that this is worthwhile. In the high temperature stage superheater at 850 F, the material contains 1.25 per cent chromium, 0.55 per cent molybdenum, and 0.75 per cent silicon. In the medium temperature range, tubing is used which contains 5.00 per cent chromium, 0.55 per cent molybdenum and 0.70 per cent titanium. In the 1050 F range, tubing is used which contains 17 to 20 per cent chromium, 9 to 13 per cent nickel and 0.60 per cent titanium. Special welded joints had to be developed, particularly where the austenitic and ferritic steels were joined together.

Truck capacity is dependent not only on the weight of the load but also on the overhang. Truck is shown lifting 60,821 lb.



Typical of modernized materials handling methods in the steel plant is this view of a rubber tired tractor hauling a special car for coils.

That perennial problem, flyash, may turn out to be an asset instead of a liability. It is being used as a fine aggregate in cinder concrete, as a substitute for clay in building blocks, as a filler in bitumastic road construction, in sand blasting and as a partial replacement for Portland cement. This latter use is the most widespread and the use of flyash additive increases the workability of cement, and under some conditions a stronger concrete is the result. Over 140,000 tons of flyash are being shipped from Chicago to be used in the 3,000,000 cu yd of concrete required for the Hungry Horse Dam in Montana.

A gas turbine power plant installation which went into operation during the year was designed for 5000 kw generator terminal output and has an expected thermal efficiency of 28 per cent based on the generator terminal output and on the lower heating value of the fuel. The normal rating of such power plants is affected by ambient temperature and also by altitude. The unit will require only about 1200 gpm of water for coolers which is ⅓ to ⅕ that required for an equivalent steam station. Installation costs will be relatively low and the entire power plant unit can be placed in a space 50 ft long by 28 ft wide by 13 ft high and the total weight is about 60 lb per kw.

A 2000-hp gas turbine unit was installed in a natural gas pipeline for pumping natural gas. The unit can burn natural gas or liquid fuel. This particular installation is of interest because extensive field studies are being planned on its operation. Commercial applications of the unit will depend a great deal on the results of the tests. The gas turbine has 8 stages designed for equal heat drops over the stationary and rotating blades. Complete unit is mounted on bedplate 20 ft long, 5 ft wide, and 4½ ft high.

An important development in materials occurred in the making of cast iron. One of the reasons gray cast iron has been used is that the graphite flakes characteristic of gray iron are responsible for the excellent machinability, wear resistance and damping capacity of such iron. These flakes at the same time have been responsible for its weakness and brittleness, for the shape of the flakes is such as to set up stress concentrations at the edge of the grains. If the graphite could be introduced in a nodular or spherical form, the iron would retain some of the advantageous characteristics and eliminate some of the undesirable factors. In 1949 a process was announced which uses magnesium as an addition. With this addition, nodular cast iron can be produced in the as-cast form without subsequent heat treatment. Cerium can be also used for the same purpose, but in this case the iron must be hypereutectic, or the total carbon content, plus one-third the silicon and phosphorus contents must exceed 4.3 per cent and this limits the use of this material. It has been known for some time that magnesium would form nodular iron, but the problem has been to introduce the magnesium so that it would be retained and also in such a way that explosions or fires would not occur. Procedures have now been developed, however, to introduce a nickel-magnesium alloy in the molten iron, and this development now opens up economical commercial development of the nodular iron.

The field of ultrasonics, long a plaything in the laboratory, opens many opportunities for practical application, because of the development of sources for the waves. One piece of equipment is called a sonic generator, and one of the units now offered has a frequency range of 500 to 22,000 cycles per sec with an output up to 300 watts and with intensity levels up to 165 decibels. This unit consists of a motor-driven rotor facing a stator, with precision matched ports around the periphery of each. Compressed air or other gas passes through a flanged inlet into the generator housing, thence through the ports of the rotor and the stator. As the rotor turns, automatically closing and opening the ports of the stator, compressed air flows out intermittently through the stator ports generating an intense sound wave. The intensity of the wave is governed by the pressure of the compressed air, and the frequency by the speed at which the rotor is driven. These units are now being used successfully in commercial fine dust and mist collection systems, particularly for particles smaller than ten microns in diameter. The unit acts to agglomerate these particles into clusters large enough to be separated by cyclone separators.

Another application, mentioned in the finishing section of this report has been the application of ultrasonic waves in frequencies up to 33,000 cycles per sec for degreasing. This was done in a magneto-striction transducer, which is a unit made of an alloy of nickel and cobalt made to oscillate by a high frequency electric current. The high frequency current creates an alternating magnetic field, which in the steel plant tests changed direction 33,000 times a sec.

Another method of producing the sound waves (particularly for frequencies above 100,000 cycles a second) is by the use of crystals which have piezoelectric characteristics. Piezoelectric materials are those which have the property of sending off sound waves when an electric current is passed through them or, in other words, they convert the electric current to sound. Such units offer possibilities for emulsifying non-miscible liquids, and they enable powdered materials of different characteristics to be put in liquid suspension. They also apparently increase the activity of electrolytic agents in plating operations.

A welding process has been recently adapted to the successful welding of stainless steel. This process is basically an inert gas-shielded metallic arc which involves the continuous feeding of a coiled wire electrode in a gaseous shield through the barrel of a welding gun.

High speed deposition of filler metal in all positions with both manual and automatic equipment is accomplished.

A submerged arc welding head was developed during the year which enables welding in inaccessible locations such as on the inside of box girders.

Stack-cutting with the oxyacetylene torch has been used for many years, but the operation has required various layers of steel to be in very intimate contact so that the pile of steel acted essentially as one solid piece of metal. In order to do this, very exhaustive clamping measures have been required to eliminate air gaps. The flux-injection method developed for the cutting of stainless steels has been found to be very effective in stack-cutting other materials, without the clamping formerly required, and the air gap which would stop the cut in a normal operation apparently has no effect.

A torch was invented during the year which will develop higher temperatures than any previous unit, temperatures hot enough to cut holes in firebrick and hot enough to melt tungsten. This torch is still in the laboratory stage and is an electronic device which combines high frequency radio signals up to 1,000,000,000 cycles per sec with various gases. Leading from the torch are two antenna where the high frequency arc is formed, and where nitrogen, or carbon dioxide, or other gas are fed past the arc. The resulting torch resembles a jet of flame about 9 in. long. The torch is similar to the atomic hydrogen torch in that the molecules break down to atoms, and these in turn are combined again into molecules, which latter reaction provides the intense heat.

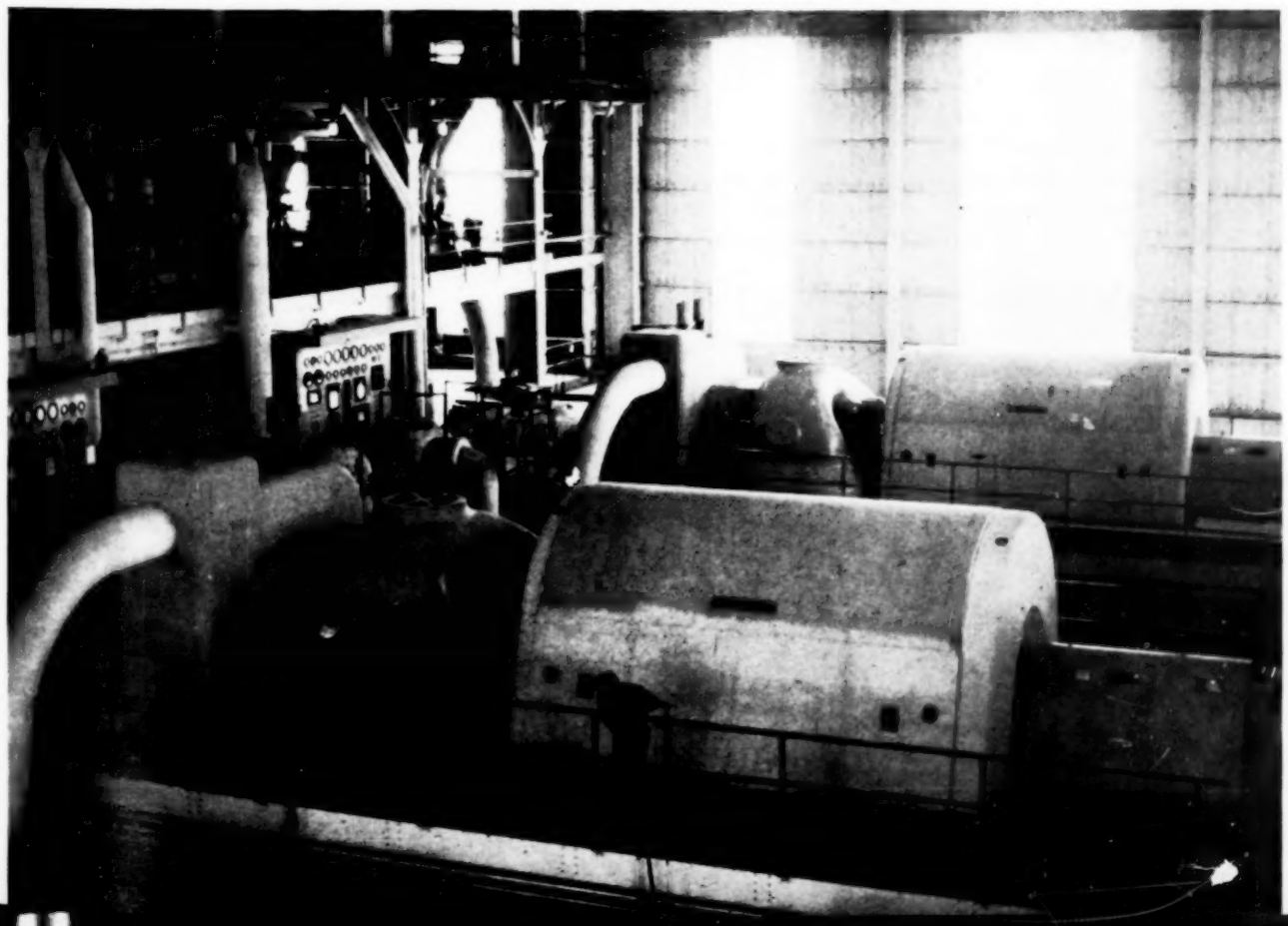
An unusually novel device developed during the year is a spring which has negative force deflection characteristics. In other words this spring resists less the more it is deformed. Other unusual characteristics are that the spring has an extremely large range of action (50 times original dimension) can act around corners and through small openings, has a very high initial force in resisting the first increments of deflection, and it can store and deliver about twice as much energy as an ordinary spring occupying the same space. This device promises many varied uses.

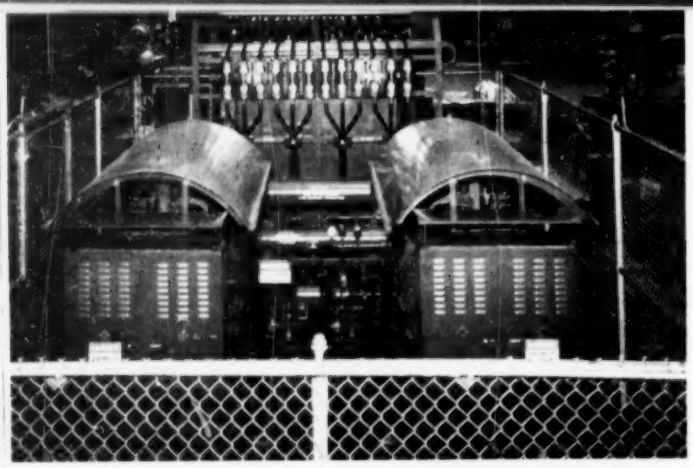
Automatic lubrication for pressure lubricated plug valves became possible during the year without the use of mechanical accessories because of the development of a compressible valve lubricant. Because of the compressibility feature, the material can be put into the system under pressure and as the old lubricant works out, lubrication still takes place because of the elastic characteristics of the material.

Of interest to the utilities men in steel plants are the leak detectors which have been developed from which leak surveys can be made of the utility lines in the plant without uncovering any of the units. The instrument used is similar to a mine detector and it is relatively simple to locate lines, find leaks and locate fittings.

A radically new pump was introduced during the year which has no blades, thus reducing the possibility of clogging. In this pump the fluid is introduced into a rotating tube that is wound in a helix which starts at a small radius at the axis of rotation, and then fans outward in a helical spiral. The centrifugal force drives the fluid against the sides of the tube and goes out through

The Pennwood power station has two 30,000-kw turbo-generators operating on 850-psi, 900-F steam. About 80 per cent of the steel plant's power requirement is now generated by the plant.





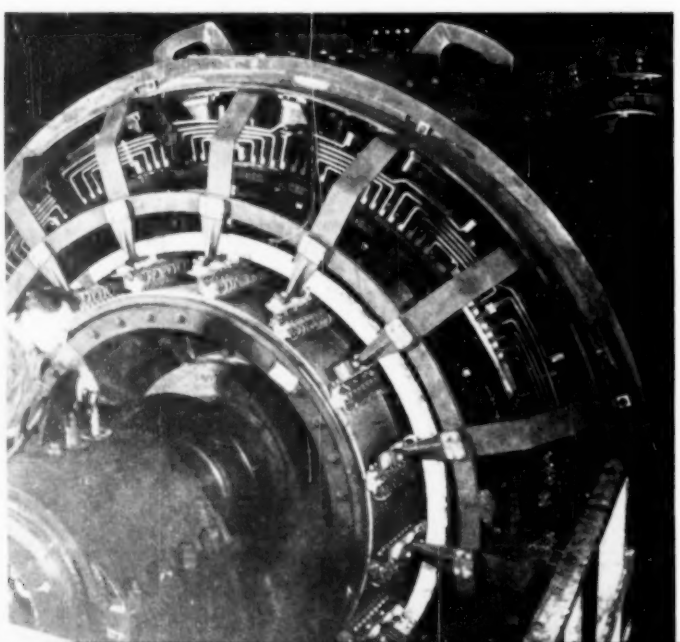
Rectifier units have proved serviceable for steel mill operations. This 1000-kw unit is located in the Chicago district.

an outlet in the casing. The pump can handle much larger trash than ordinary pump units and it does not have to be oversize to allow passage of trash.

In an attempt to speed up the machining of high strength metals, methods have been developed in which the work is heated to temperatures from 1000 to 1500 F and then machined at the higher temperatures. The resultant effects are faster cutting, reduced power and better tool life.

One problem which created a furor during the year was that of smog. This was highlighted at Donora, Pa., where about 20 fatalities occurred because of some substance in the air. At the present time the cause and source are unknown and debatable, but suits have been entered against the American Steel and Wire Co. which has a plant in the town. The report which was made by the public health service on the disaster at Donora stated only that an intense smog composed of chemical compounds in the air apparently made many people sick, some of whom died as a result. The important item of the report, however, is that it definitely concludes that people can get sick and die from air pollution.

Twin drive unit for 206-in. mill has two 4000-hp, 30/75-rpm, 600-v reversing motors replacing a 15,000-hp twin tandem, cross-compound steam engine.



This subject has become a sore point even in such areas as Los Angeles, and, in various areas, legislation is being formulated and planned which will have a great deal of effect on what impurities may be vented to the atmosphere.

Allegheny County, which includes the Pittsburgh area, passed a smoke control ordinance on May 17 last year. This ordinance says essentially that plants should not make smoke, and this is defined in general as anything exceeding a density equivalent to No. 2 of the Ringlemann chart. The method of meeting this is left up to the individual plant. Some of the efforts made to meet this requirement are as follows: The Jones and Laughlin Steel Corp. installed a new central boiler house whose dust collectors meet the law's requirements. A new sintering works is planned for the Edgar Thomson Works and another for the Carrie furnace. The Carnegie-Illinois Steel Corp., has also appropriated $100,000 for a pilot plant at the Etna ferro-manganese furnaces. In the Pittsburgh area, industrial plants will have one year to meet smoke regulation and will have five years to come up with a plan to control fire ash.

ELECTRICAL DEVELOPMENTS

Expansion of central station capacity in the United States reached an all time peak in 1949 with additions of 6,929,201 kw costing $2,000,000,000. Total installed capacity at the end of the year was about 63,000,000 kw, compared with 56,500,000 at the beginning of the year. Total power consumption in 1949 was 291,000,000,000 kwhr compared with 283,000,000,000 kwhr in 1948. The industry's reserve capacity which had averaged 6 per cent at the end of 1948 went up to about 12 per cent by the end of 1949. As a result the industry started to push selling as it had done before the war. However, there were certain areas where it was difficult to meet some of the high peak demands.

A great deal more electric power will be incorporated into the end product of steel as ore beneficiation becomes a larger factor in steel production. Inasmuch as it has been estimated that 60 to 75 kwhr are required to produce one ton of concentrate from taconite, large power installations will be required. In some locations this may be a limiting factor in the expansion of beneficiation plants.

The first hot strip mill in the country to use rectifiers alone for converting the a-c supplied to the mill to the d-c required by the drive motors, and installed during the year, is a semi-continuous hot strip mill. Two of the drive motors on this mill are rated at 5000 hp each.

During the year an 8000-hp, 40/80 rpm, twin motor drive was put into service on a 46-in. blooming mill at a Northern Ontario plant.

During the year improvements were made in the static magnetic amplifier. This equipment uses one or more saturable core reactors in such a way as to secure a very high gain. Although the principle has been known for some time, development of special circuit arrangements have widely enhanced the possibilities for this equipment. Since this is a static device, maintenance is at a minimum, and the unit is quiet in operation. Amplifications of 10 to the 12th power have been obtained in one stage of the unit. The equipment offers applications for amplifying signals in control circuits such as voltage and frequency regulators, motor controls, audio amplifiers and in general the uses which

ELECTRIC MOTORS OVER THREE HUNDRED HORSEPOWER

APPLIED TO MAIN ROLL DRIVES IN THE IRON AND STEEL AND ALLIED INDUSTRIES DURING 1949

Item	Horsepower	Revolutions per minute	Volts	Frequency	Method of drive	Type of mill	Purchaser	Location	Manufacturer
1	300	300/600	230	d-c	Geared		McLouth Steel Co.	Detroit, Mich.	Westinghouse
2	300	300/1250	600	d-c	Geared	Reel, 48-in. skin pass tension	SOLLAC	France	Westinghouse
3	300	514	2300	60	Geared	8-in. Merchant mill	Laclede Steel Co.	Alton, Ill.	Westinghouse
4	400	300/1100	375	d-c	Geared	Reel, 3-Stand tandem mill	Thomas Steel Co.	Warren, Ohio	Westinghouse
5	400	575/1150	250	d-c	Direct	Foil mill	Aluminum Co. of America	New Kensington, Pa.	General Electric
6	400	270/675	600	d-c	Geared	Cross country rod and bar mill	Compagnie de Forges & Aciéries	France	Elliott
7	400	270/675	600	d-c	Geared	Cross country rod and bar mill	Compagnie de Forges & Aciéries	France	Elliott
8	400	500/1250	250	d-c	Geared	Sendzimir mill	Empire Aluminum Co.	Scotland	Elliott
9	500	400/800	230	d-c	Geared	80-in. Hot strip-edger No. 1	SOLLAC	France	Westinghouse
10	500	375	350	d-c	Geared	80-in. Hot strip-squeezer	SOLLAC	France	Westinghouse
11	500	600/1200	600	d-c	Geared	17½-in. x 48-in. Aluminum foil mill	Trefileries & Laminoirs Du Havre	Paris, France	General Electric
12	500	600/1200	600	d-c	Geared	17½-in. x 48-in. Aluminum foil mill	Estab. Charles Coquillard	Forges (Isere), France	General Electric
13	500	250/700	600	d-c	Direct	Reversing cold mill	Wallace Barnes Co.	Bristol, Conn.	General Electric
14	600	300/600	250	d-c	Geared	10-in. Skelp mill	Youngstown Sheet & Tube Co.	Indiana Harbor, Ind.	General Electric
15	600	250/875	600	d-c	Geared	No. 2 Skin pass mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
16	600	250/875	600	d-c	Geared	No. 3 Skin pass mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
17	600	150/300	600	d-c	Direct	48-in. Skin pass mill, stand No. 1	SOLLAC	France	Westinghouse
18	600	400/800	500	d-c	Direct	54-in. Aluminum cold mill	Reynolds Metals Co.	Lister Hill, Ala.	Westinghouse
19	600	400/800	500	d-c	Direct	54-in. Aluminum cold mill	Reynolds Metals Co.	Lister Hill, Ala.	Westinghouse
20	600	300/900	600	d-c	Geared	Tension reel	Cantieri	Italy	Westinghouse
21	600	300/900	600	d-c	Geared	Tension reel	Cantieri	Italy	Westinghouse
22	600	690/1380	375	d-c	Geared	Continuous seamless tube mill	Globe Steel Tubes Co.	Milwaukee, Wis.	Allis-Chalmers
23	600	690/1380	375	d-c	Geared	Continuous seamless tube mill	Globe Steel Tubes Co.	Milwaukee, Wis.	Allis-Chalmers
24	600	300/600	600	d-c	Geared	12-in. Bar mill	Bethlehem Steel Co.	Lackawanna, N. Y.	Elliott
25	700	400	2300	60		Merchant mill	Laclede Steel Co.	Alton, Ill.	Westinghouse
26	800	450/1150	600	d-c	Geared	3-Stand tandem cold mill	Thomas Steel Co.	Warren, Ohio	Westinghouse
27	800	250/545	600	d-c	Direct	3-Stand tandem cold mill	Thomas Steel Co.	Warren, Ohio	Westinghouse
28	②800	250/1100	600	d-c	Direct	Tension reel, 48-in. cold mill	SOLLAC	France	Westinghouse
29	①800	400/750	600	d-c	Direct	48-in. Skin pass, stand No. 2	SOLLAC	France	Westinghouse
30	①800	400/750	600	d-c	Direct	Tension device, 48-in skin pass	SOLLAC	France	Westinghouse
31	②800	200/700	600	d-c	Geared	Reel, 75-in., 4-stand tandem mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
32	②800	200/700	600	d-c	Geared	Reel, 54-in. 4-stand tandem mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
33	800	360/900	600	d-c	Geared	Cross country rod and bar mill	Compagnie de Forges & Aciéries	France	Elliott
34	800	360/900	600	d-c	Geared	Cross country rod and bar mill	Compagnie de Forges & Aciéries	France	Elliott
35	800	360/900	600	d-c	Geared	Cross country rod and bar mill	Compagnie de Forges & Aciéries	France	Elliott
36	900	225/725	600	d-c	Geared	Tension reel	Republic Steel Corp.	Cleveland, Ohio	Westinghouse
37	1000	375	3000	50	Geared	80-in. Hot strip mill scale breaker	SOLLAC	France	Westinghouse
38	1000	350/726	600	d-c	Direct	3-Stand tandem cold mill	Thomas Steel Co.	Warren, Ohio	Westinghouse
39	②1000	250/1000	600	d-c	Geared	Reel, combination cold sheet and strip mill	Societe Anonyme-Phenix Works	Liege, Belgium	General Electric
40	③1000	250/1000	600	d-c	Geared	Reel, combination cold sheet and strip mill	Societe Anonyme-Phenix Works	Liege, Belgium	General Electric
41	②1000	600/1200	600	d-c	Direct	9½ in.-24 in. x 48 in. Aluminum foil mill	Estab. Charles Coquillard	Forges (Isere), France	General Electric
42	②1000	600/1200	600	d-c	Direct	9½ in.-24 in. x 48 in. Aluminum foil mill	Trefileries & Laminoirs Du Havre	Paris, France	General Electric
43	1250	690/1050	550	d-c	Geared	Rod mill	Chiers	Belgium	Westinghouse
44	1250	690/1050	550	d-c	Geared	Rod mill	Chiers	Belgium	Westinghouse
45	1250	500/1000	600	d-c	Geared	Cross country rod and bar mill	Compagnie de Forges & Aciéries	France	Elliott
46	1500	300/600	600	d-c	Geared	Billet mill	Oesterreichisch Alpine Montangesellschaft	Donawitz, Austria	General Electric
47	1500	360	6600	60†	Geared	Billet mill	Sheffield Steel Corp.	Houston, Tex.	General Electric
48	1500	360	6600	60†	Geared	Billet mill	Sheffield Steel Corp.	Houston, Tex.	General Electric
49	1500	70/120	600	d-c	Direct	48-in. Cold mill, stand No. 1	SOLLAC	France	Westinghouse
50	1750	175/350	600	d-c	Direct	Cold mill	Cantieri	Italy	Westinghouse
51	2000	90/225	600	d-c	Direct	54-in., 4-Stand tandem mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
52	2500	90/200	600	d-c	Direct	75-in. 4-Stand tandem mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
53	2500	130/260	580	d-c	Direct	Reversing hot strip mill	Fagersta Bruks Aktiebolag	Fagersta, Sweden	General Electric
54	①2500	50/100	625	d-c	Direct	36-in. Blooming mill	Yugoslavia	Zenice, Yugoslavia	General Electric
55	①2500	50/100	625	d-c	Direct	36-in. Blooming mill	Yugoslavia	Zenice, Yugoslavia	General Electric
56	②2500	125/312	600	d-c	Direct	48-in. Cold mill-stand No. 2	SOLLAC	France	Westinghouse
57	3000	210/420	600	d-c	Direct	Combination cold sheet and strip mill	Societe Anonyme-Phenix Works	Liege, Belgium	General Electric
58	②3000	225/450	600	d-c	Direct	48-in. Cold mill-stand No. 3	SOLLAC	France	Westinghouse
59	②3500	330/660	600	d-c	Direct	48-in. Cold mill-stand No. 4	SOLLAC	France	Westinghouse
60	3500	150/300	700	d-c	Direct	66-in. Hot strip mill	Austrian Iron and Steel	Austria	Westinghouse
61	3500	500	13,200	50	Geared	80-in. Hot strip roughing stand No. 1	SOLLAC	France	Westinghouse
62	3500	150/300	600	d-c	Direct	54-in. 4-Stand tandem mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
63	②3500	200/450	600	d-c	Direct	54-in. 4-Stand tandem mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
64	②3500	250/550	600	d-c	Direct	54-in. 4-Stand tandem mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
65	①4000	30/75	600	d-c	Direct	34-in.-50-in. x 206 in. Plate mill	Lukens Steel Co.	Coatesville, Pa.	General Electric
66	①4000	30/75	600	d-c	Direct	34-in.-50-in. x 206 in. Plate mill	Lukens Steel Co.	Coatesville, Pa.	General Electric
67	4000	175/350	700	d-c	Geared	66-in. Hot strip mill	Austrian Iron and Steel	Linz, Austria	Westinghouse
68	4000	175/350	700	d-c	Geared	66-in. Hot strip mill	Austrian Iron and Steel	Linz, Austria	Westinghouse
69	4000	175/350	700	d-c	Geared	66-in. Hot strip mill	Austrian Iron and Steel	Linz, Austria	Westinghouse
70	4000	125/250	700	d-c	Direct	66-in. Hot strip mill	Austrian Iron and Steel	Linz, Austria	Westinghouse
71	4000	132/296	700	d-c	Direct	80-in. Hot strip finishing stand No. 10	SOLLAC	France	Westinghouse
72	①4000	50/120	800	d-c	Direct	44-in.x108 in. Reversing blooming mill	Oesterreichisch Alpine Montangesellschaft	Donawitz, Austria	General Electric
73	①4000	50/120	800	d-c	Direct	44-in.x 108-in. Reversing blooming mill	Oesterreichisch Alpine Montangesellschaft	Donawitz, Austria	General Electric
74	4000	125/250	600	d-c	Direct	75-in. 4-Stand tandem mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
75	②4000	160/320	600	d-c	Direct	75-in. 4-Stand tandem mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
76	②4000	180/400	600	d-c	Direct	75-in. 4-Stand tandem mill	Bethlehem Steel Co.	Lackawanna, N. Y.	General Electric
77	4500	500	13,200	50	Geared	80-in. Hot strip-roughing stand No. 2	SOLLAC	France	Westinghouse
78	4500	500	13,200	50	Geared	80-in. Hot strip-roughing stand No. 3	SOLLAC	France	Westinghouse
79	4500	500	13,200	50	Geared	80-in. Hot strip-roughing stand No. 4	SOLLAC	France	Westinghouse
80	4500	125/282	700	d-c	Geared	80-in. Hot strip-finishing stand No. 5	SOLLAC	France	Westinghouse
81	4500	125/282	700	d-c	Geared	80-in. Hot strip-finishing stand No. 6	SOLLAC	France	Westinghouse
82	②4500	460/920	600	d-c	Direct	48-in. Cold mill-stand No. 5	SOLLAC	France	Westinghouse
83	4500	375	6600	25	Geared	79-in. Hot mill, stand No. 3	Bethlehem Steel Co.	Lackawanna, N. Y.	Westinghouse
84	4500	160/320	600	d-c	Geared	79-in. Hot mill-stand No. 10	Bethlehem Steel Co.	Lackawanna, N. Y.	Westinghouse
85	5000	78/156	700	d-c	Direct	80-in. Hot strip-finishing stand No. 7	SOLLAC	France	Westinghouse
86	5000	105/210	700	d-c	Direct	80-in. Hot strip-finishing stand No. 8	SOLLAC	France	Westinghouse
87	5000	125/250	700	d-c	Direct	80-in. Hot strip-finishing stand No. 9	SOLLAC	France	Westinghouse
88	7000	40/100	700	d-c	Direct	Blooming mill	Austrian Iron and Steel	Linz, Austria	Westinghouse
89	7000	600	6000	50*	Geared	Billet mill	Oesterreichisch Alpine Montangesellschaft	Donawitz, Austria	General Electric

*Indicates synchronous motor †Indicates induction motor ①Twin motor drive ②Double Armature ③Triple Armature

MOTOR RECAPITULATION

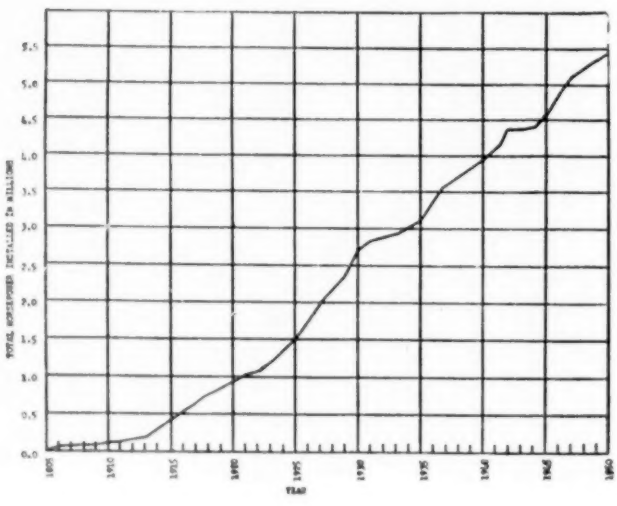
Company	Location	Type of mill	Number of motors	Total horsepower
Aluminum Co. of America	New Kensington, Pa.	Foil mill	1	400
Austrian Iron and Steel	Linz, Austria	66-in. Hot strip mill	5	19,500
		Blooming mill	1	7000
Bethlehem Steel Co.	Lackawanna, N. Y.	Skin pass mill	2	1200
		12 in. Bar mill	1	600
		54-in. 4-Stand tandem mill	5	13,300
		75-in. 4-Stand tandem mill	5	15,300
		Stand No. 3-79 in. hot mill	1	4500
		Stand No. 10-79 in. hot mill	1	4500
Societe Anonyme-Phenix Works	Liege, Belgium	Cold sheet and cold strip mill reels	3	5000
Cantieri	Italy	Cold mill	3	2950
Chiers	Belgium	Rod mill	2	2500
Compagnie de Forges & Accieries	France	Cross country rod and bar mill	6	4450
Yugoslavia	Zenice, Yugoslavia	36-in. Blooming mill	2	5000
Empire Aluminum Co.	Scotland	Sendzimir mill	1	400
Estab. Charles Coquillard	Forges (Isere), France	17½-in. x 48-in. Aluminum foil mill	1	500
		9½-in.-24 in. x 48 in. Aluminum foil mill	1	1000
Fagersta Bruks Aktiebolag	Fagersta, Sweden	Reversing hot strip mill	1	2300
Globe Steel Tubes Co.	Milwaukee, Wis.	Continuous seamless tube mill	2	1200
Laclede Steel Co.	Alton, Ill.	8-in. Merchant mill	2	1000
Lukens Steel Co.	Coatesville, Pa.	34-in.-50 in. x 206 in. Plate mill	2	8000
McLouth Steel Corp.	Detroit, Mich.		1	300
Oesterreichisch Alpine Montangesellschaft	Donawitz, Austria	Billet mill	2	8500
		44-in. x 108-in. Reversing blooming mill	2	8000
Republic Steel Corp.	Cleveland, Ohio	Tension reel	1	900
Reynolds Metals Co.	Lister Hill, Ala.	54-in. Aluminum cold mill	2	1200
Sheffield Steel Corp.	Houston, Tex.	Billet mill	2	3000
SOLLAC	France	48-in. 5-Stand cold mill	6	15,800
		48-in. Skin pass mill	4	2500
		80-in. Hot strip mill	13	47,000
Thomas Steel Co.	Warren, Ohio	3-Stand tandem mill	4	3000
Trefileries & Laminoirs DuHavre	Paris, France	17½-in. x 48-in. Aluminum foil mill	1	500
		9½-in.-24-in. x 48-in. Aluminum foil mill	1	1000
Wallace Barnes Co.	Bristol, Conn.	Reversing cold mill	1	500
Youngstown Sheet & Tube Co.	Indiana Harbor, Ind.	10-in. Skelp mill	1	600

Type of motors purchased	Number of motors	Total horsepower
Alternating current motors	11	33,500
Direct current motors	78	160,100
Total	89	193,600

are now performed by thyratrons, rotating regulators and some vacuum tubes. The static magnetic amplifier is being used for loop control in pickling lines, bus voltage regulators for hot strip mill rectifiers, tension reel regulating systems for tandem cold strip mills, and winding reel and current limit control.

Several mechanical rectifiers have been put into operation. These operate similarly to the mercury arc rectifier, but metallic contacts synchronously driven are utilized for conducting, instead of an electronic stream. The ohmic drop of the metallic contacts is insignificant compared with the arc drop of the mercury arc rectifier which results in very high efficiency, particularly in the range from 50 to 400 volts. In this voltage range, the unit is available in six sizes from 200 to 10,000 amp.

The cumulative curve of main drive motor over 300 hp shows a total to January 1, 1950 of 5,459,690 hp. Eighty-nine motors (193,600 hp) were added in 1949.



The maximum size of transformers produced in 1949 went to 145,000 kva compared with a maximum of 110,000 kva in 1948. A 10,000,000 kva oil circuit breaker was built during the year which is more than double the previous ratings.

Of interest to purchasers of steel mill cranes is the revision of the Association of Iron and Steel Engineers "Specifications for Electric Overhead Traveling Cranes for Steel Mill Service," AISE Standard No. 6, revised May 1, 1949. This revision includes extensive changes in gearing, motor and wiring clauses.

An interesting development in crane control which gives a-c cranes the desirable characteristics now associated with d-c control is the use of an eddy current brake to preload a wound rotor motor. Although this type of control was used on other equipment during the war, its application to cranes is very recent.

It has been found that a tetrafluorethylene resin used in insulation of motors and transformers enable operation of these units at temperatures as high as 400 to 500 F, as far as the insulation itself is concerned. During the year a new brand of copper was put on the market which is claimed will permit higher current loadings because improved annealing characteristics incorporated in the production of the wire permits higher current loading. This is done by adding minute amounts of hardening agents to very pure electrolytic copper. Because of the controlled composition, the material has consistent uniform properties. Tests have shown that this copper can withstand a continuous operating temperature which is 35 C higher than ordinary commercial copper.

Electric Equipment for Rolling Cold Strip

AT 70 MPH

. . . . progress in speeding-up strip mills would have been long since halted, if it had not been for the precise electrical control developed by the electrical equipment manufacturers and operators . . . .

By WILLIAM E. MILLER
Steel Mill Division
General Electric Co.
Schenectady, N. Y.

▲ ADVANCES in the art of cold rolling during the last fifteen years have been noteworthy. Most outstanding is the increase in rolling speeds. In 1933 strip was rolled at 800 fpm. In January of 1948 the Jones and Laughlin Steel Corp. successfully rolled tin plate at 6250 fpm on their new tandem cold mill at Aliquippa, Pa.

First placed in service in October, 1947, the new J&L five-stand mill is of interest not only because it is the world's fastest mill, but also because it was the first tandem mill to go in service with a separate generator for each stand, the first five-stand tandem mill to have separate drives on each work roll of the last three stands, the first tandem mill with rotating regulator controlled adjustable voltage screwdowns, and the first to make use of the new X-ray thickness gage.

finish to tinplate and sheet gages. Strip as thin as 0.0066 in. and as heavy as 0.235 in. has been rolled. When rolling at 6000 fpm, a 15-ton coil can be rolled into tinplate in about 5 minutes.

The electric motors have a nominal capacity of 16,850 hp rated on a 40 C rise basis with forced ventilation. Supplied with full Class B insulation, the motors will supply 20,100 hp continuously without injurious heating. Data on the drives are given in Table I and Table II.

There are two main drive motor-generator sets, each consisting of a 10,000-hp synchronous motor with three d-c generators. The three generators of one set serve stands No. 1, 2 and 3, and the other three serve No. 4

TABLE I

MAIN DRIVE DATA

Stand	Total hp	No. of armatures	Type of drive	Motor rpm	Gear ratio	WK² in lb-ft² at motor shaft x 1000			Per cent amp to accelerate mill and motors*	Per cent amp to accelerate motors only*
						Motor	External	Total		
1	1750	1	SA	80/240	1:1	123	38.5	161.5	33.0	25.0
2	3500	2	DA	150/360	1:1	100	38.5	138.5	31.8	23.0
3	3500	2	SA-T	175/350	1:1.525	74	96.2	170.2	36.9	15.8
4	3500	2	SA-T	200/400	1:2	66	192.0	258.0	73.0	18.7
5	4000	4	DA-T	275/535	1:2	36	192.0	228.0	101.0	15.9
Reel	600	2	DA	300/1200	1:1	3:1	3.6	6.7	99.5	46.0

SA — Single Armature. DA — Double Armature. SA-T — Single Armature, twin drive.
DA-T — Double Armature, twin drive.
*Acceleration in 10 sec from rest to top rated speed with weak field setting on each motor.

MILL EQUIPMENT

The mill consists of five four-high stands and winding reel. The work rolls are 21½ in. in diameter, when new, and have a face length of 42 in. The back-up rolls are 53 in. in diameter with a 42 in. face. The mill housings weigh 120 tons each and have column sections 30 by 38 in. The mill weighs 4000 tons and is placed on reinforced concrete foundations extending into bedrock 50 ft below ground level.

The mill will roll strip up to 36 in. wide and will

TABLE II

MAIN GENERATOR RATINGS

Motor-generator set No.	Stand No.	Generator kw rating	Generator voltage
1	1	1500	750
1	2	3000	750
1	3	3000	750
2	4	3000	750
2	5	3200	750
2	Reel	500	750

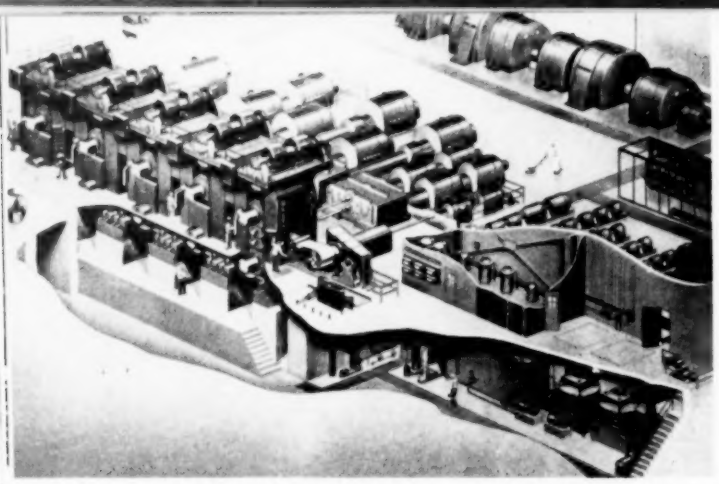


Figure 1 — General arrangement of equipment on the high speed cold mill at Jones and Laughlin Steel Corp., Aliquippa, Pa. Works.

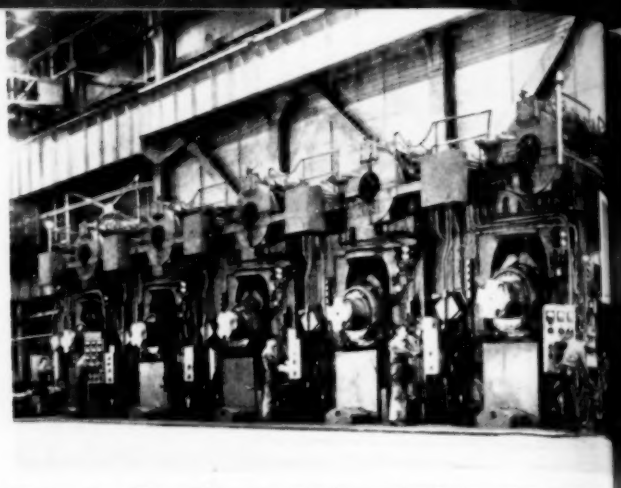


Figure 2 — The 70-mph tandem tinplate mill is here shown in operation.

and 5, and the tension reel. The total nominal generator capacity is 14,200 kw. The generators have a continuous overload rating equivalent to that of the motors.

A rotating regulator power factor regulator is provided which changes the field strength of the motor-generator set synchronous motors in proportion to the load they are carrying. It can be set to maintain constant power factor, or constant reactive kva.

LAYOUT AND MECHANICAL ARRANGEMENT

Main drive motors, motor generator sets and control equipment are located in a new motor room laid out for the equipment. Motors, motor generator sets and control are on the main floor. Ventilating equipment, main drive direct current line panels, and main motor generator set field application and neutral reactor equipment are located in the basement.

The ventilating system is of the down draft recirculating type with surface air coolers and air filters. Air from the motor room passes through the main drive motors and into a tunnel beneath the motors. A fan is located at each end of the tunnel and draws the air through surface air coolers and dry type filters, exhausting it back into the room. The motor generator sets are ventilated in a similar manner.

Makeup air equipment consisting of a blower, air washer, and electrostatic type air filter is used to supply clean air to make up for any leakage in the ventilating system, and to maintain the entire system at a slightly positive pressure to exclude dirt and dust, vapors, etc.

MAIN DRIVE CONTROL

The majority of the tandem mills which have been in service for more than a year are equipped with separate d-c motors on each stand, supplied as a group with d-c power from one generator, or a group of generators connected to a common bus and operating as a unit. The majority of the high-speed, high-power tandem mills put into service during the last year differ in that an individual generator supplies power to each stand motor. The J&L five-stand mill was the first tandem mill to go into service with this new type of control system.

The choice of the basic control scheme is a matter of economics, operation and maintenance. Certainly, on a high-speed high-power mill, the advantages are in favor of the individual-generator scheme. First, the use of a separate generator for each stand considerably increases the flexibility of the mill. Adjustments between mill stands can be made by generator voltage control as well as by motor field control. Second, the heavily supported high current bus is eliminated. Third, but of prime importance, electric gage control can be included without using high current series booster generators.

On a high speed tandem mill, electric gage control during the mill accelerating and decelerating periods is a "must." There are several factors which affect the strip gage during these periods. First, the gage will be heavier at low speeds than at high speeds, and heavier at low tensions than at high tensions, if all other factors remain constant. Second, there will be a variation in gage if there is a variation in the relationship between stand speeds.

If moments of inertia (motor plus mill) are properly balanced between stands, each motor will require the same per cent current for acceleration. If, in addition, the per cent rolling load on all stands is the same, and if the per cent speed regulation is the same and if the per cent operating speed of all motors is the same, then as the mill is accelerated and decelerated, all motors will remain in speed correspondence. If a variety of

Figure 3 — The view of the motor room shows main drive motors in foreground with main control auxiliary sets, and 440 volt a-c control in background.

products is to be rolled on a mill, the adjustment required between stands by motor field control alone is such that all the conditions given are not satisfied. Practical limitations in motor and mill design also limit the extent to which it is possible to balance the moments of inertia. To illustrate data on the J&L mill are given in Table I.

Therefore, to maintain proper gage during periods of threading, or low speed operation, and during acceleration and deceleration, the electric gage control system should compensate both for unbalance in moments of inertia between stands and for the tendency for the gage variation during steady state rolling conditions. To obtain such a correction it is necessary to have a system wherein the mill is "stretched out" as the operating speed is lowered, rather than a system acting to maintain perfect speed correspondence.

In addition, the system should sense variations at normal operating speeds and correct for them. Probably the predominating cause for off gage while at running speed is the variation in incoming strip. If the entering strip suddenly becomes heavy, the first pair of rolls in the tandem mill will spring slightly. Since it is more difficult to reduce the strip in each succeeding stand, the rolls in each succeeding stand will probably spring a progressively greater percentage. Thus, there is a tendency for the strip to slow down. If constant relative roll speeds are maintained, the tension will increase. This increase in tension should attack the heavy gage and at least tend to pull it on gage. However, this increased tension, as well as the increased rolling load, would tend to slow down the motors depending upon their speed regulation. The poorer the regulation, the greater would be the drop in speed, and therefore, the less tendency to pull the strip on gage. If the last stand has the minimum permissible speed regulation and each preceding stand has slightly greater speed regulation, the mill should sense and correct for gage variations better than if all stands had the same minimum amount of speed regulation. Therefore, any electric gage control system should also incorporate this feature. In addition, experienced rollers know that the amount of electric corrective effect that can be used satisfactorily is dependent upon the product being rolled and the conditions under which it is being rolled. For maximum benefit the adjustment should be simple and readily available to the operator.

There are two methods of obtaining electric gage control which have been reported upon before the AISE. The first is by automatic control of the shunt field strength of one or more of the stand motors, the method being called "tapered-tension control by motor field adjustment." The second is by an independent control of motor armature voltage by an amount equal to or a part of the IR-drop in the system, the method being called "IR-drop compensation."

With the separate generator scheme, a separate regulating system is used on each stand. Electric gage control may easily be incorporated into this regulating system. Tapered tension by armature voltage control and IR drop compensation may both be incorporated into the voltage regulating system.

Tests reported upon before this Association show that trouble from strip breakage is experienced when the mill load characteristic is made too flat, i.e., when 100 per cent IR compensation is approached. A high gain or fast and accurate speed tie, or position tie between stands will give such a characteristic. Low gain speed regulating systems will have some load regulation corresponding to less than 100 per cent IR compensation, but will also be affected to the same extent by other changes in the regulating system. However, a high gain speed regulating system can be given a drooping load characteristic by introducing load current into the comparison or measuring circuit of the speed regulating system. Adjustment of compensation is then from approximately zero speed regulation to drooping as compared to a voltage regulating system with IR compensation where adjustment is made from a base of normal motor speed regulation to somewhat less than flat.

A small tapered tension effect is obtained due to the decrease in per cent speed regulation from the first stand motor to the last stand motor. This can be increased by tapering the adjustment of the amount of IR compensation from a small amount on the first stand to the maximum desired on the last stand. Such an adjustment not only helps to correct for the tendency of the mill to roll heavy at low speeds, but also helps to correct for variations in incoming gage.

The individual generator system using high gain, high response rotating voltage regulators with adjustable IR compensation included is extremely simple in circuit and adjustment. With this system it is possible to obtain IR-drop compensation, an appreciable tapered tension effect, and also to have a system which will sense and correct for variations in incoming gage. Excellent operating results have been obtained by using a tapered IR compensation set-up with the amount of compensation on the last stand varying from 30 to

Figure 4 — The main drive control panel for mill and reel motors and generators. Adjustable voltage and rotating regulator control are used throughout.

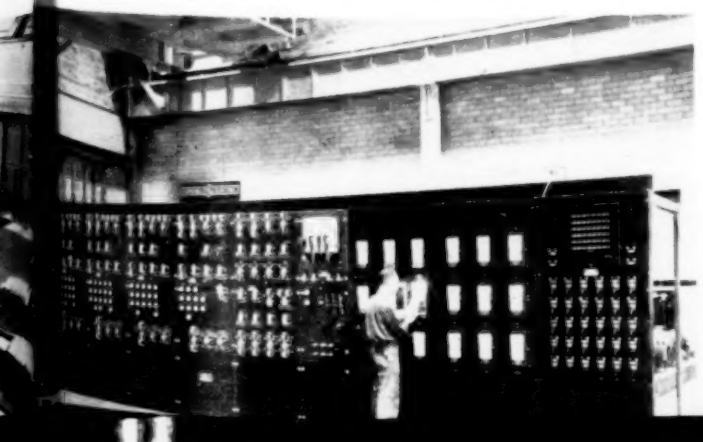


Figure 5 — AISE 612 screwdown motors are used on J & L 5-stand mill.

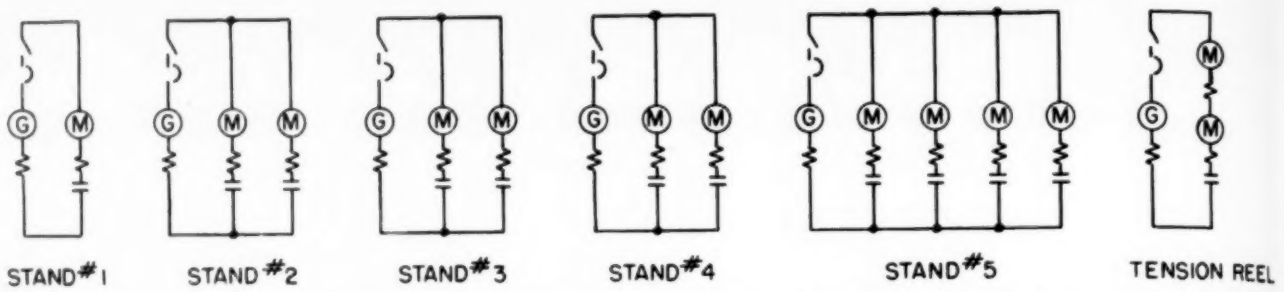


Figure 6 — Armature circuit connections for a five-stand tandem tinplate mill with individual generator for each stand and IR compensation included in regulating control system. Dynamic-braking resistors and contactors are not shown. Total motor capacity is 16,850 hp.

75 per cent, depending upon the type of material being rolled.

Additional complexities would be introduced into the regulating circuit if speed regulators were used. Adjustment of individual stand speed is usually by means of a motor operated coarse rheostat and a hand operated vernier rheostat. With speed regulators it would be necessary to recalibrate the regulating circuit every time the rheostats were changed. This would require an additional dial on both the motor operated rheostat and on the hand operated rheostat.

MILL SPEED CONTROL

The regulating control system for the individual generator scheme for one stand is shown in Figure 7. The mill master rheostat determines the voltage on the master voltage control bus MP1 and MP2. This bus is the standard by which the voltage on every generator is controlled. By raising or lowering the voltage on this bus, it is possible to raise or lower (proportionately) the voltages of all the generators. The mill master rheostat also controls the excitation on the generator-field exciter GFE which supplies all stand generators. In this way, regulating exciters RE on each stand can operate buck-boost at low voltage levels ideal for fast regulator action.

Each stand has a motor operated stand speed adjusting rheostat for coarse adjustment and a hand operated rheostat for vernier adjustment. The motor operated rheostat has two or more dials. Dial A gives individual voltage adjustment on each generator. Dial B controls individual stand motor shunt field excitation. The dials are arranged so that operation at reduced voltage is obtained with full field. However, regardless of the settings on the stand-speed adjusting rheostats, or the vernier rheostats, the mill master rheostat will raise or lower each generator voltage proportionately.

It has already been pointed out that it is usually desirable not only to control all generator voltages so that they are proportional to the voltage on the master voltage control bus, but also to compensate for IR drop in all motor-armature circuits. In this way, the speeds of all motors may be held closely proportional to the voltage on the master voltage bus. It can be seen in Figure 7 that the ohmic-drop exciter OD receives its excitation from the voltage drop across the generator commutating field, and its output voltage may be made equal to (or any fixed percentage of) the motor-armature circuit IR drop, and for control purposes may be automatically subtracted from the generator terminal voltage. Each stand regulator, through its regulating exciter RE, then acts to hold essentially motor counter emf which is a measure of motor speed.

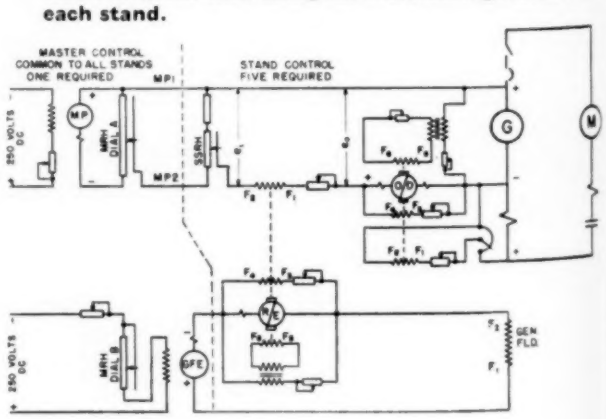
Two transformers are used to obtain voltage rate of change signals for stabilization. The ohmic-drop exciter OD is also used as an amplifier for the voltage rate of change signal fed back from the main generator G. The rotating regulator amplifier used for this application is ideally suited for its dual purpose because of its high gain and very low time constant. The time constants of amplidyne OD, as shown in Figure 7, are less than $\frac{1}{300}$ of the main generator time constant.

The use of rotating regulators permits positive stopping of the mill without opening either the generator breakers, or the motor line contactors and without complication of the regulating systems. When the voltage on the master voltage bus is reduced to zero, the high gain regulating systems cause the residual voltage on the generators to be reduced to substantially zero. The voltage level is low enough to prevent the motors from creeping even with the work rolls removed.

TWIN DRIVE REGULATING SYSTEM

As cold strip mills operate at higher and higher delivery speeds, it becomes increasingly important to keep the peripheral speed of the upper and lower working rolls the same at all times. On the finishing end of a mill rolling thin gage, there is considerable pressure between rolls even with no metal in the mill. With any difference in working roll diameters on a pinion-driven

Figure 7 — Rotating voltage regulating system with ohmic-drop compensation for one stand of a five-stand tinplate mill using an individual generator for each stand.



mill, this will tend to promote slipping between one roll and the strip or if the mill were empty to make the rolls grind each other and cause their surfaces to become rough. This is avoided with separate roll drives, or twin drives, which permit the rolls to be operated at slightly different angular speeds.

The regulating control system for the twin drive for stand No. 5 is shown in Figure 8. The rotating regulating system is arranged so that load balance is obtained between armatures A and B and between C and D and also between armatures B and C. Armatures A and B drive the top roll and armatures C and D drive the bottom roll.

Proper operation may be assumed when the peripheral velocities of the two rolls are equal and when the work done by each roll on the strip is the same. If it is assumed that the top work roll is larger in diameter than the bottom roll, then the top work roll must be made to revolve at a lower angular velocity and still produce the same amount of work. This means that its torque must be increased. Since the armatures operate in parallel and, therefore, at the same voltage, a regulating system acting to make all armature currents equal by varying field excitation will fulfill the requirements of the system.

Operation at high speeds with the twin drive systems described above has been most satisfactory. Material as thin as 0.0066 in. has been finished at 4000 fpm, and 0.011 in. at 6250 fpm. Tinplate was rolled at 5200 fpm with work rolls in Stand No. 5 differing in diameter by 0.254 in. The tinplate was of the highest quality and after rolling what was considered to be the normal period for a set of finishing stand rolls, the rolls were examined carefully and found to be normal in appearance.

Variations in the distribution of strip lubricant between the top and bottom of the strip will cause variations in the division of rolling load between the top and bottom motors. It has been found that the best quality strip is rolled with less strip breakage when the load balance regulating system is adjusted for extremely fast action to quickly limit wide swings. In addition the loop gain of the regulating system should be set so as to permit some variation in load between top and bottom motors to compensate for the ordinary variations in the distribution of lubricant. Such an adjustment tends to loosen by one more step the rigid mechanical tie which exists on a pinion driven mill.

REEL TENSION CONTROL

The control circuit for the tension reel is shown in its simplified form (less stabilizing elements) in Figure 9. The system is arranged so that the reel generator voltage is proportional to strip speed. Dial C of Stand No. 5 speed selecting rheostat provides the proper reference signal for the tension reel voltage regulating system.

Reel build up and automatic tension control are taken care of by a current regulator. This regulator acts to maintain constant reel motor armature current by changing the shunt field excitation on the reel motor. As the coil builds up, the regulating control system automatically increases the shunt field excitation to reduce the angular speed of the reel motor and to increase the motor torque in proportion to the build-up to maintain constant tension in the strip.

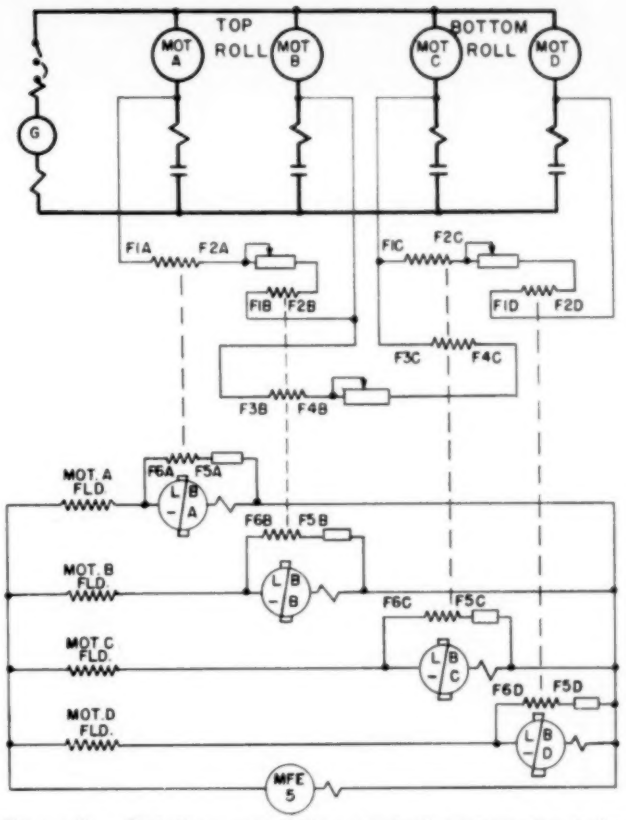


Figure 8 — Rotating regulating control system for twin drive for stand No. 5 of a five-stand tinplate mill.

CIRCUIT CONSTANTS FOR OPTIMUM PERFORMANCE

In no other type of rolling mill does the performance of electric equipment affect the quality of the product to a greater extent than in the cold strip mill. The accuracy of the gage, the ease of maneuvering, the mill tonnage, and the per cent yield all depend directly upon how well the electric drive system is coordinated. Not only must the system be designed to operate over an extremely wide range of steady state operating conditions, but it must be designed to have a high rate of response so that changes in operating conditions may be made quickly with all stands acting together.

Regulating circuits of the type shown in Figures 7, 8 and 9 are also called servomechanisms. The study of such circuits has been both intensive and extensive during the past few years. Actual circuits have been tested to study transient performance in the laboratory, factory, and field. System studies have been made on differential and transient analyzers. Complete servomechanisms have also been analyzed by the frequency response methods of Nyquist and Bode. By correlating the data available, it is possible to analyze the systems of Figures 7, 8 and 9 by the frequency response method, and to select the circuits and circuit constants which will give the desired system performance.

The complete rotating type voltage regulating control circuit for one stand of the new J&L tinplate mill

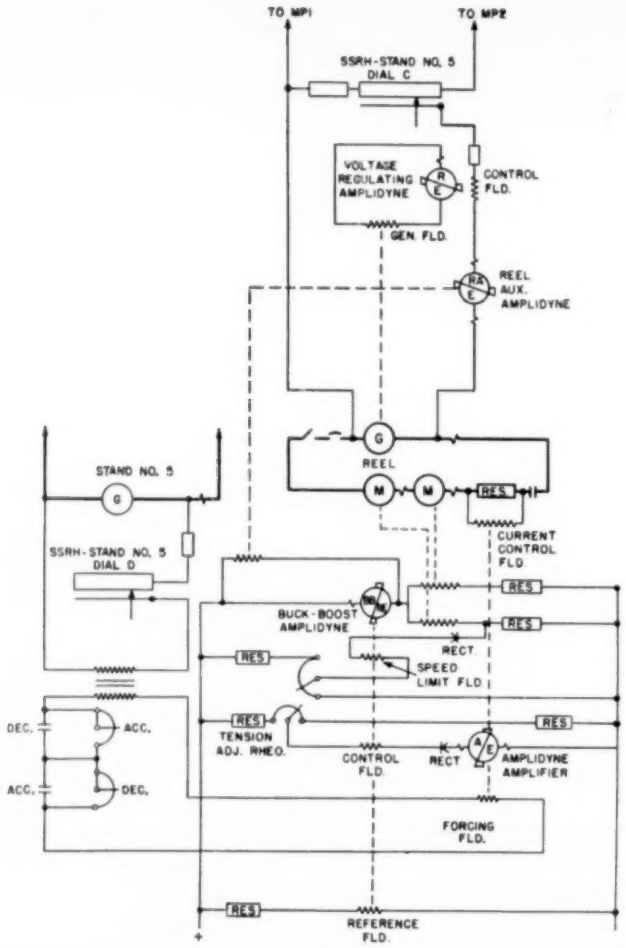


Figure 9 — Rotating regulating control circuit for tension reel on a tandem cold-strip mill, showing tension (current type) regulator and voltage regulator following reference set up by last mill stand.

is shown in Figure 7. The control for every other stand is identical.

The block diagram for the regulating system of Figure 7 is shown in Figure 10. In constructing the diagram, it was assumed that the error introduced by considering the generator voltage feedback signal to be proportional to the rate of change of internal voltage instead of terminal voltage is small.

The basic method of analysis and the mathematical justification of the frequency-response method of analysis have been completely presented in available published literature. Briefly, it is necessary to apply an alternating input signal of constant magnitude and varying frequency to the input side of the system and to determine both the magnitude of the output signal and its phase relation with the input signal. The frequency response must be determined over the whole frequency spectrum of the system. To do this mathematically, it is usual practice to break the system up into its component parts, as shown in Figure 10 and to determine the transfer function of each part. These transfer functions are then combined either mathematically or graphically to obtain the system transfer function and the system frequency response. From a study of the frequency response and phase characteristics of the system components and the whole system, it is possible to select and adjust circuits so as to cause the system to have the desired transient characteristics.

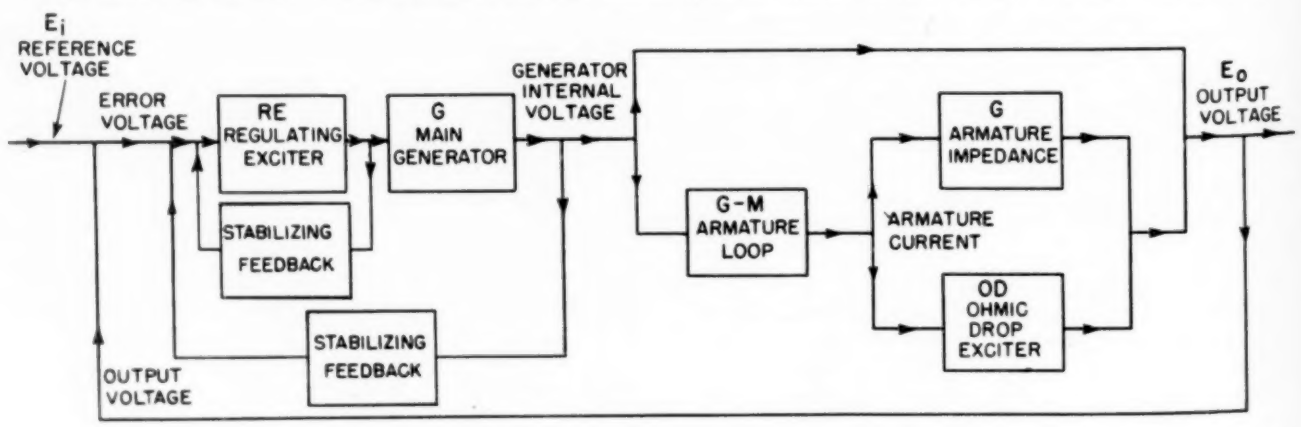
Frequency response curves for the voltage regulating system shown in Figure 7 are given in Figure 11. It is seen that the effect of IR compensation is to increase the peak response of the system. However, with 75 per cent compensation, the peak is well within the limits recognized as required for good performance. Actual operation has been checked with an oscillograph. Motor speeds follow all operating changes in reference accurately and without overshooting. Tests have been made and reported upon before the AISE upon the advantages and disadvantages of IR compensation. A study of the results of these tests indicates that 75 per cent IR compensation is about the maximum amount which can be used to advantage on a system made up of modern mill type motors and generators.

ROTATING REGULATION CONTROL SCREWDOWNS

Screwdown equipment on the new J&L five-stand mill is such as to make the screwdown action the fastest in response and speed of any tandem mill. Screwdowns operate with a 400:1 total ratio and are driven by two 75 hp No. 612 motors. Adjustable voltage control with rotating type regulators is used for speed and load limit control.

The control provides for duplex operation, or opera-

Figure 10 — Block diagram for rotating voltage regulator with IR compensation for one stand of a five-stand tandem cold strip mill using individual generator for each stand. (The schematic control circuit is shown in Figure 7.)



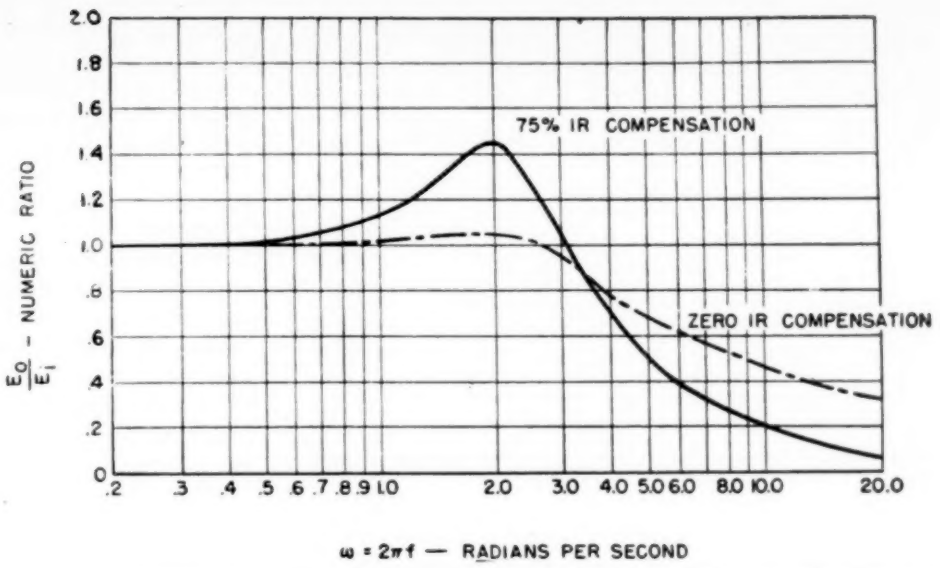


Figure 11 — Frequency response of voltage regulator with IR compensation for stand No. 5 of tandem tinplate mill (motor operating with weak field).

tion of the individual screws. For duplex operation a magnetic clutch couples the two motors together to operate as a single unit in the up or down direction. During duplex operation, two speeds are provided in either direction. High speed operation is at double voltage. Load balance is also provided so that each motor will share the load equally. Fast acceleration is provided by current limit control. Acceleration is forced by the control system until the limiting value of current is reached, it is then held until the operating condition is reached.

Each screwdown generator has its armature directly connected to its motor. Fast response and accuracy of the rotating regulating systems permits the elimination of line contactors and brakes.

X-RAY THICKNESS GAGE

An X-ray thickness gage is used on the J&L mill to insure accurate measurement of strip gage as the finished strip is delivered from the last stand. The gage is operated in the usual manner by setting the gage indicator at the gage desired to be held, inserting a test strip of the thickness to be rolled in the X-ray beam, and setting the zero on the gage deviation indicator. Since the X-ray thickness gage does not have any short time drift, is not affected by changes in ambient, or strip speed, it requires a very minimum of checking and readjustment. In addition, it need not be moved away from its operating position for the front end or tail end of the strip or for welds at any rolling speed.

The gage is designed upon the basis that equal parts of X-ray beams will be transmitted if beams from a common source of X-radiation pass through sheets of the same material having the same thickness. Both the reference beam and the measuring beam are obtained from the same X-ray tube. The reference beam continuously penetrates a standard wedge within the gage. The measuring beam simultaneously penetrates the strip being rolled and a deviation wedge. The deviation wedge is positioned automatically as a function of strip thickness to maintain the relation:

Deviation Wedge Thickness + Strip Thickness = Gage Wedge Thickness

The operator watches the deviation dial as it follows the continual repositioning of the deviation wedge. The accuracy and reliability of the X-ray gage have made it an essential part of the new J&L five-stand mill.

COLD STRIP MILLS

There are five tandem cold mills now in service which have electric equipment and individual generator control systems of the type described in this paper. Control systems on all five mills were designed using the frequency response method of determining transient performance.

Mill operating and maintenance men are well satisfied with the individual generator scheme employing voltage regulation with adjustable IR compensation. Simplicity of control system and predetermination of system transient performance have reduced field adjustments to a minimum. Increased flexibility in setting up rolling schedules through adjustment of stand generator voltage, elimination of high current series IR compensation boosters, and reduction of current capacity of d-c buses are factors of such importance on the modern high-speed high-power tandem mills that it is felt that all future installations will be of this type.

Within its short life, the performance of the J&L mill has made history and has been widely publicized. The fruits of the engineering achievements incorporated into this mill and the others described, have been the rolling at record speed of record quantities of quality tinplate and sheet. At J&L 2150 tons of tinplate have been rolled in a 24-hour period, over 800 tons in an eight-hour period, and 115 tons in an hour. Another of these tandem mills is now rolling products ranging from 0.0094 to 0.065 in. thick, the tinplate being rolled at speeds up to 3500 fpm and the heavy sheet at speeds up to 1800 fpm.

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DISCUSSION

PRESENTED BY

G. E. STOLTZ, Consulting Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.

R. M. PEOPLES, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

WILLIAM E. MILLER, Steel Mill Division, General Electric Co., Schenectady, N. Y.

G. E. Stoltz: A number of papers have been read before the AISE on the subject of production of strip steel. To this record Mr. Miller has added a most interesting paper outlining a number of developments made on a very successful five-stand tandem cold reduction tinplate mill. Considerable development has been required to bring the art of producing cold strip to its present state; and while the present up to date tandem cold tinplate mills are giving a remarkable performance, I am sure Mr. Miller will agree that there are still further refinements to be made. For this reason, we need not lose interest in a development program which has held our attention for several years.

Holding gage is usually obtained by an increase or decrease of tension between stands, either automatically or by manipulation of the field rheostat of one of the driving motors. The chief occasion of over-gage is when the mill is brought to a slow speed. During normal rolling, there is no particular difficulty in maintaining gage. One very successful method is to maintain gage out of No. 1 stand. This usually leaves very little correction to be made in the delivery end of the mill as the gage should be held automatically if it is correct out of No. 1 stand.

Considerable over-gage is obtained when some mills are slowed down even from 2000 fpm. We would, therefore, expect greater over-gage on present day mills that operate from 4000 to 5000 fpm. The installation of IR-drop generators and magnetizing exciters on each main drive motor will cause the individual motors to retain their high speed relationship even down to very low threading speeds. If close to full compensation is used, this type of control will tend to maintain gage throughout the period the mill is slowed down, but the tension may be increased to such an extent that the strip will break. This places a limit on maintenance of gage as it is preferable to produce a certain amount of over-gage rather than to have an abnormal number of breaks in the mill.

The amount of tension which can be put on the strip depends upon the character of the steel. If very good steel is being rolled, the tension values can be increased during the slowdown period to a high value, but if there are defects present, considerably less tension may be the practical limit.

It is our practice to provide control which will bias the speed of the motors to accommodate a certain amount of over-gage. The amount and time of biasing is variable and can be adjusted by the operator from time to time depending on the section he is rolling and the quality of the steel.

The amount of over-gage obtained seems to vary with mill practice. Last year we supplied the electrical equipment for a four-stand tandem sheet mill which rolls both tinplate and sheet, and found that while we had provided control to bias the speed of the last two motors, no biasing was required, as there was very little variation in gage as the mill slowed down. Since electrical manufacturers cannot predict the performance of a mill on which they supply electrical equipment, it is necessary to furnish control that has a broad adjustment which can be utilized when the mill is placed in operation.

It may be that I have not properly understood Mr. Miller's comment in regard to the influence of moment of inertia of the rotating parts on each stand. If correct IR drop compensation and magnetization are used, the motors should give practically the same response whether the inertia loads are light or heavy. It would be quite difficult to balance the inertia of each stand in order to require the same per cent full load torque for acceleration and retardation even without field speed adjustment; but with the latter, it is seldom, if ever, that inertia compensation would be the same. On some schedules, the roughing stand motors are operating near full field while the finishing stand motors are at a highly weakened field position. On other schedules, the reverse is true. The only way to obtain uniform response from the individual motors is to provide correct IR drop and magnetization compensation whether it be a common bus or a separate generator installation.

Mr. Miller has outlined the advantages of the use of separate generator drive over that of the common bus. Of the recent equipments we have supplied, and are in the process of manufacture, three are for common bus operation and nine for separate generator. The separate generator supply requires an appreciable increase in accurate regulating control which is not needed if the common bus system is used. I believe there are installations, particularly where the speed range of the motors can cover the variety of product rolled, where the common bus is preferable as it constitutes a simpler system than the use of separate generators. Separate generator drive, however, as Mr. Miller states, has definite advantages for many mills.

Our first experience with twin-motor drive on cold reduction mills was on a four-stand sheet and tin mill placed in operation January, 1947. Its performance has been eminently satisfactory and parallels to a large extent the results outlined by Mr. Miller on the five-stand tandem tinplate mill he described.

In May, 1947, a five-stand tandem cold mill was placed in operation with our electrical equipment which was provided with twin-motor drives on the last two stands. As a precaution, the mill manufacturer provided a locking gear which could be installed if twin-motor operation was not preferred. This mill was operated for some time as a twin-motor drive on the last two stands but, later the locking gear was placed in operation which ties the two working rolls together. The operators of this mill are still using the locking gear as it is their feeling better performance is obtained than when the two working rolls are driven separately. At another plant, our equipment is being installed on two five-stand tandem cold tinplate mills by a prominent manufacturer of tinplate with standard pinion drive on all stands. It is obvious that field experience will be needed to weigh the advantages of the twin-motor and pinion drive. Personally, I believe there is much in favor of twin-motor units applied to the finishing stands of a high speed mill.

The tonnage output quoted in Mr. Miller's article indicates the importance of not only having a good mill, properly designed electric drive, but also good welds. The electric drive and the mill may be of the highest order; but if the welds are poor and break easily, high speeds are impractical and high tonnage impossible.

While the cross-section of the steel finished is not given, if we assume it to be 0.01 in. by 30 in., the average speed of the mill would have to be 3830 fpm to produce 115 tons per hour, and 3330 fpm to produce 800 tons in eight hours. Unless the cross-section of the material rolled at this time was greater than I have assumed, to obtain these tonnages would require not only high speed operation but also very few delays.

High speed mills of the character described roll four or five hot mill coils welded together often totaling 30,000 lb. If too large a percentage of welds will not withstand the tension between stands, it is necessary to slow the mill down in order to avoid too much damage in case of a break. This slowing down may decrease the possible tonnage output from 10 to 15 per cent.

The hot mill coils are welded at the entry of the pickle line and the pickling line which serves the mill described by Mr. Miller is provided with a welding unit which has at least two new features which we believe contribute to better welds. One is the hydraulic push-up and the other is the use of timed ignitron tubes to apply the power to the welder.

A description of this welder is given in "Flash Welding of Wide Strip Steel," by F. R. Thomson, and F. J. Waldschutz, Iron and Steel Engineer, August 1949, p. 35. Considerable study was made by the engineers of the Jones and Laughlin Steel Corp., and our own on the type of control applied to this welder. The chief advantage of the electronic ignitron tube is that the amount of current flowing can be accurately controlled at any instant, either during the inrush, the heating cycle, or the push-up. The tubes also have the advantage that they cut off the current at a definite time and do it sharply. The performance of a contactor will vary with burning of the contacts and also wearing of the bearings. Records show that the performance of this welder, both mechanically and electrically, constitutes a contribution to supplying the mill with improved welds.

R. M. Peoples: Everyone who is working in the steel industry and everyone who is a member of the electrical profession serving that industry has been, of course, extremely interested in the developments in new mill electrical equipment as exemplified by the new installation at J. & L. We in our capacity as electrical equipment manufacturers, have been no less interested in the recent trend, principally because our work on new mills has been closely paralleling the ideas put into this unit.

We therefore, believe it would be appropriate to add a few remarks to show that the developments of the art as contained in this job are also going forward in other quarters.

In attacking the electrical problems involved, we have found ourselves thinking along lines a great deal similar to those Mr. Miller has shown, although the techniques of execution are different in some respects. One thing seems startlingly clear. To one who must choose between the separate generator control and the common bus scheme, it seems evident that the individual generator idea is the idea for the modern high-power mill, once of course the practical working ability is proven. This is not to say that the common Ward Leonard bus is obsolete for you will find that on the lower powers the economic aspects often sway the decision for the common bus, although even there the possibility of flexibilities in machines and voltages offer interesting comparisons.

It has not been emphasized very strongly in connection with this high speed discussion, but I might point out the obvious fact that using a separate generator lineup also enables mill operation on a given schedule at lower speeds. This means a gain in motor torque per armature ampere and therefore for any given installation, wider widths may be rolled up to the point where 100 per cent motor torque is utilized all along the line. It certainly seems evident that this system then gives the operator more mill than a common bus hookup.

At the present date one four-stand tandem mill has been operating since December, 1947, with individual generator control built by my company or two months less than the mill described. Just recently two double stand tin temper mills with individual generators and control have gone into production rolling up to 3300 fpm. This mill employs nine motors driven from six generators. A two-stand tandem mill with individual generators is now awaiting final erection details and will be started up shortly.

The four-stand tandem mill has been rolling product from 0.007 to 0.065 in. at rates up to 2800 fpm. The response characteristics of the mill with an inertia lineup very similar to the mill described in this paper have been good. Gage is commonly maintained until the tail of the strip is out of No. 1 stand at thread speed and attained quickly on acceleration. The tie in characteristics between motors was checked by a test set up at the factory. The factory calculations were put on the

control to roll the first coil successfully and have never been changing except for IR adjustment.

On the temper mill, the entry and delivery units are used under voltage regulation at thread speed and transferred to current regulators when the mill is under way. By introducing an electrical bias from a tensiometer into the voltage regulating circuit, similar to the method of IR compensation shown by Mr. Miller, one of the main stands is put under the control of an automatic tension regulator for controlling the tension between the two drives. It is evidence, that once you establish the initial voltage regulating circuit, it can very easily be introduced in the circuit and you have a regulator of any quantity you might desire. Production results on these units have been very good.

On the two-stand aluminum mill rather than use straight IR compensation, it is planned to balance or bias the motor droops using a comparison circuit introduced into the voltage regulator.

All of the various mills mentioned employ a basic counter emf method of regulating speed which lends itself easily to the regulation of other quantities (as desired) by simply biasing the voltage regulator initially established. Regulation is attained with high response rotating regulator machines.

It has been our experience to date that very little trouble originates with these regulating systems. They are stable and consistent in operation, requiring very little maintenance. Based on the use of a good regulator it would seem that these schemes are both practical and versatile.

William E. Miller: I am pleased to note that the discussers agree so closely on our interpretation of the requirements of the control systems. I agree most heartily with Mr. Stoltz that one of the most important of these on the modern high speed, high power mill is to have the proper amount of IR compensation, or its equivalent, available at the proper time. To do this the system must be set up so that the amount of compensation is readily adjustable, the adjustment is simple, and available to the mill operator. Performance is sacrificed when this is not or cannot be done. I want to thank Mr. Stoltz for helping to clarify this general subject. It is a complex one and even two explanations may be considered to be none too many.

We have never found it necessary to include magnetizing exciters on an installation of this type. All motors on these mills were designed to have the same speed regulation at both top and base speeds. With such a design it is possible to eliminate quite a number of small rotating machines on installations such as we are considering.

Now since we have all agreed upon the importance of IR compensation, it appears to me that its necessity rather than the shape of the mill speed cone should be the determining factor as to whether we use the separate generator scheme or the common bus scheme. Let us consider the Jones & Laughlin mill. If we had used the common bus scheme, we would probably have had two generator voltage regulating systems, one for the stands and one for the reel. However, we would have had five large high current IR compensation booster generators plus all of their control equipment. If the IR compensation were to be fast enough to be of value during transients, we would also have had to provide IR compensation regulating systems, each requiring a rotating regulator for forcing. After all, IR compensation is of little value if it comes on several seconds after it is required. Thus to do the same job not nearly as well, the so-called "simpler" common bus scheme would have actually required not only a more expensive installation, but one more rotating machine as well.

It seems to me that any circuit complexities because of accuracy requirements are probably a result of the type of regulating system used rather than simply the change from the common bus scheme to the separate generator scheme. After all, the rotating type of voltage regulator used in recent years has never been condemned as too complicated for the value received. The fact that high accuracy and high speed of response were not required in some of the previous installations does not necessarily mean that to obtain them the regulating system must become more complex. The proper selection of new circuit constants may be all that is necessary. In fact, that was what was done. Inclusion of the IR compensation function in a regulator is a simple job.

Theoretically, it should be possible to get about the same performance with a speed regulator as with a voltage regulator with IR compensation. But certain things peculiar to tandem cold mills make it extremely difficult to do so. The same steady-state accuracy will be required for both systems. The big difference in requirements is in transient response. To be satisfactory from a transient standpoint, the regulating system must be damped so that all changes are corrected for without overshoot. With the voltage regulating system with IR compensation, all large changes in reference are controlled and uniform. They are made by the motor driven master rheostat, or by the controlled emergency stopping circuit. A simple system easily can be adjusted to operate without overshoot under such conditions.

With a speed regulating system, your transient performance is at the mercy of the operator's wrist. If he has a weak wrist and turns the motor field vernier slowly, you recalibrate your reference slowly and do not cause the system to overshoot. However, if he has been used to lots of range in the vernier and has a strong wrist, oscillations and strip breakage are bound to occur. Also, since the speed regulator will effect the change long before the motor field change is effected, the speed regulated system will always tend to give a transient over-correction for a quick change in vernier setting. This is not possible with the voltage regulated system with IR compensation since no changes are fed into the voltage regulating system when the motor field vernier is adjusted.

Thus, I will agree that a separate generator system with speed regulators requires an appreciable increase in accurate regulating control which is not needed if the common bus system with IR boosters is used. However, I disagree that this is the case when a separate generator system with voltage regulators with IR compensation is compared with the common bus system with IR boosters. We would supply the same voltage regulating system for both schemes and they would be very similar in circuit to those which we use on blooming mills, reversing hot mills, reversing cold mills, shears, etc.

THE ROLLING OF STAINLESS STEEL

. . . . because of its hardness at relatively high temperatures, stainless must be rolled at more closely controlled higher temperatures and in huskier mills than are required for ordinary carbon grades . . . .

By JOHN A. De FRIES*
Chief Metallurgist
Allegheny Ludlum Steel Corp.
Dunkirk, N. Y.

▲ THE rolling of stainless steel has, ever since its beginning, been considered a specialty business. The early history of stainless steel dates back to the development of the so-called cutlery irons used in the manufacture of knives and knife blades. The cutlery industry required a steel that would not rust in use and as a result of considerable experimentation and research, the cutlery irons and cutlery steels were developed. These steels were essentially a 12 per cent chromium alloy containing low carbon in the case of the cutlery iron and somewhat higher carbon in the case of the cutlery steels.

These cutlery steels were developed by the tool steel companies and acted to a large extent very similarly to the higher alloy tool steels in their hot working characteristics. They required heavy mills because of this comparatively high alloy content. The production carbon steel mills of the time were not adequate in design to successfully roll these first stainless steels. As a result, the stainless steel industry, which grew from these first stainless steels developed, has more or less been confined to the steel manufacturing plants which had tool steel business. All of the stainless steels produced today are melted in electric arc furnaces which are again most common in the alloy or tool steel companies. As a result of these factors the greater proportion of the stainless steel produced in this country is produced by comparatively small corporations who manufacture only the high alloy tool and stainless steel.

The natural starting point for any steel manufacturing process is, of course, the melt shop. Stainless steel is melted exclusively in electric arc or induction furnaces utilizing scrap of high grade and purity. As is true of any electric arc furnace melting, the scrap utilized must be carefully selected and segregated to insure the proper analysis of the finished steel. A large number of ferro-alloys are used in the melting of the various grades of stainless steel. These ferro-alloys come from all over the world and must be of good quality and uniform in analysis to result in the best quality stainless steel.

The ingot sizes used in casting stainless steel are relatively small in comparison to the production steel mills. The most common sizes for bars or wire are 8 or 12 in. sq ingots, although for larger bar and billet sizes 16 or 18 in. sq molds are sometimes used. Ingots for sheets, strip and plate may run up to as large as 18 x 30 in. or larger.

Stainless steel can be roughly divided into two distinct classifications—the chromium stainless steels and the chromium-nickel stainless steels. The chromium stainless steels are essentially alloys of iron and chromium in various amounts, and most of them are capable of hardening by heat treatment. The chromium-nickel stainless steels are alloys of iron, chromium and nickel and in almost all cases cannot be hardened by any heat treatment as they remain in the austenitic state. These properties of the two types of stainless steels determine to a large extent the handling of the various types from the ingot down. Stainless steels which harden by heat treatment will almost always harden by simply cooling in air from elevated temperatures so they must be cooled slowly after being teemed into ingots to prevent cracking due to hardening strains. The chromium-nickel steels will not harden by air cooling so no special precautions are required on these ingots.

Following the teeming of the ingots it is necessary to reheat the ingots before they can be rolled to billets. The stainless steels are very poor heat conductors, and therefore require long soaking times and slow heating rates to uniformly heat them to the rolling temperature. Due to their high alloy content the stainless steels are quite hard at rolling temperatures common to the ordinary carbon steel and it therefore becomes necessary to heat them to a higher temperature to provide the best rolling characteristics. This temperature, of course, varies considerably with the analysis but can generally be stated to be in the range of 2000 to 2350 F. At these temperatures stainless steels are quite ductile and while they are considerably harder than the ordinary carbon steels they can very readily be hot rolled.

The mills used for the working of stainless steel ingots are usually of heavier construction than those used for carbon steels and run at slower speeds. Blooming mills or three high mills are the most commonly used types of mill for the working of stainless ingots.

*Paper presented by D. S. Gormly, Assistant Chief Metallurgist, Allegheny Ludlum Steel Corp., Dunkirk, N. Y.

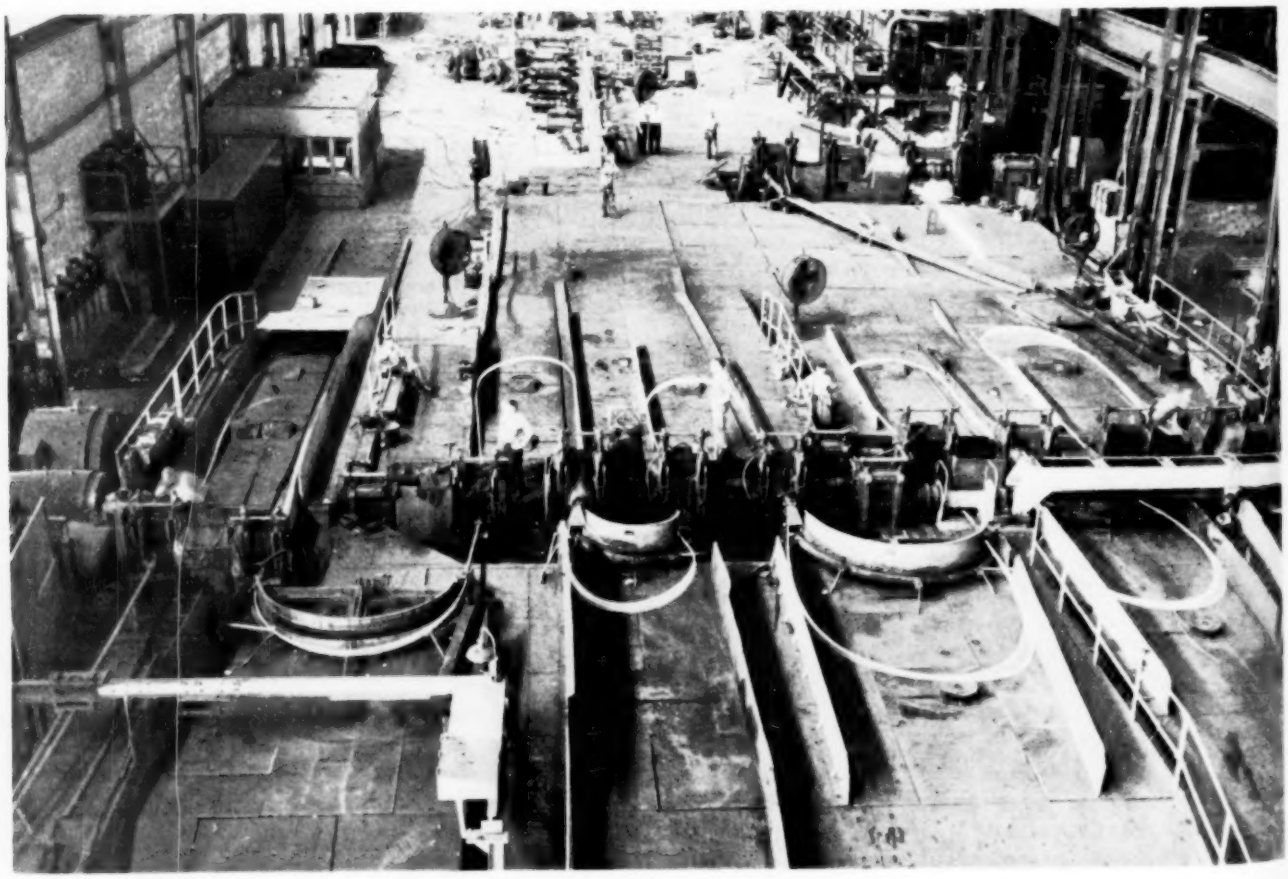
The following discussion relates mainly to bar mills. An 8 or 9 in. sq ingot in stainless steels is quite often rolled to billet on a 25 in. blooming mill or a 20 in. three-high mill. The passes in the mill are lighter than those used on carbon steels and the mills usually run at slower speeds. A common reduction for stainless steel ingots is from an 8 in. ingot to a $2\frac{1}{2}$ in. sq billet or from an 18 in. ingot to $5\frac{3}{4}$ in. sq billet.

Following the rolling of the ingot to billet, the billets are either air cooled in the case of the chromium-nickel steels, or slow cooled in the case of the hardenable chromium steels.

The billets are then conditioned to remove any surface defects which may have carried down from the ingot or occurred in the rolling operation. The usual method of billet conditioning is by grinding, in most cases, on all surfaces of the billet. This grinding operation removes any defects which may be present and conditions the billet for subsequent rolling operations. Typical defects which will be removed in the grinding operation include tears, seams, cracks, scale and other such defects common to steel rolling conditions.

Following the conditioning operation, the billets are again reheated prior to rolling to finish size. The temperatures used for the finish rolling are usually somewhat lower than those used for the rolling of the ingot to billet. Again it is necessary to heat long enough to insure thoroughly heating through the billet before rolling, taking into account the poor heat conduction typical of all stainless steels. The bar mills or coil mills used for the finishing of stainless steel bars or coils are ordinarily hand operated. Coil mills are usually a combination mill using two or more stands of a 14 in. mill for the roughing pass and then finishing through a 10 in. mill or combinations of 10 in., 9 in., or 8 in. mills. The 10 in., or combination 10-9 and 8 in. mills are so-called looping mills where the coil is looped from one stand to another. The stands are usually arranged side by side. Repeaters are usually used on one side of the mill to automatically carry the bar from one pass to the next. On the other side of the mill a man catches the bar as it comes from the mill, twists it 90 degrees and inserts it into the next pass. Because of the necessity of this 90 degree twist it is not possible to use repeaters on both sides of the mill. Normal finishing speed for a modern stainless coil mill working on $\frac{1}{4}$ in. coil is approximately 1500 fpm. Stainless steel cannot be rolled on a continuous mill such as used for carbon steel. The most common sizes of stainless steel coils finished on such a mill as just described would range from $\frac{1}{4}$ in. round up to approximately $\frac{5}{8}$ in. round. Coil weights run from 200 lb in the $\frac{1}{4}$ in. size to 400 lb in the larger sizes. The common billet size for such a mill would be $2\frac{3}{4}$ in. sq or $3\frac{1}{4}$ in. sq. The design of the passes through such a mill is quite complicated, but it can be roughly stated that the coils are reduced in a series of oval and square passes until to the last pass which is a round. Other shapes, such as squares, flats, hexagons, and octagons, can be rolled on these mills in coils.

The 14 in. - 10 in. coil mill shown is used for reducing stainless at the Dunkirk plant of the Allegheny Ludlum Steel Corp.



There are many sizes of mills used for the finishing of stainless steel bars depending, of course, on the size of bar desired. The present discussion will be limited to the smaller mills used for finishing bars up to approximately 4½ in. round. The larger sizes from 1 in. round to 4½ in. round or equivalent section in flats, squares, or other shapes, are finished usually on 14 in. mills of the three-high type. Again the stands of the mill are placed side by side in a row and usually consist of from 4 to 6 stands. This type of mill is often referred to as a merchant mill and is usually entirely hand operated as far as manipulation of the bar is concerned. For smaller sizes under 1 in. round, a 10 in. mill is used sometimes in combination with a 14 in. roughing mill. As in the case of the mills used for the rolling of ingots these finishing mills are of heavy construction and operate at relatively low speeds due to the high hardness inherent in stainless steel. Again the reductions in each pass can be described as a series of ovals and squares until the finished size is reached.

After the stainless bars or coils are finished rolled, they are either air cooled in the case of the non-hardenable types or slow cooled in the case of those steels which will harden appreciably by air cooling.

There are many different types of stainless steel and each has its own peculiarities of hot working in regard to rolling temperature, ease of hot working and tendency to develop defects. The free machining types which usually contain an appreciable amount of sulphur or other free machining additions have to be rolled at extremely high temperatures in order to prevent splitting or cracking. Stainless steel is noted for being abrasive or galling when it comes in contact with other materials. This characteristic shows up in hot working in that guides, repeaters, etc., will show wear very quickly and can readily cause scratching or other defects on the bars or coils being rolled. It is necessary to use materials for the guides, etc., which will minimize any galling or scratching. Frequently brass or cast iron guides are used and repeaters are lined with brass or a similar low friction metal.

Mill conditions for the rolling of these stainless steels must be closely controlled to prevent the occurrence of overfills, laps, seams, scratches, etc.

Perhaps a few words concerning the metallurgical aspects of stainless steel would be in order at this point as their metallurgical properties in many cases govern this behavior during the rolling operation. As previously mentioned stainless steels can be roughly divided into two classes, those hardenable by heat treatment and those not hardenable by heat treatment. The first class consists entirely of an alloy of iron and chromium with no appreciable amount of nickel. These steels in the annealed condition are relatively soft, can be readily formed or machined, and are capable of developing a fairly high hardness by heat treatment. They are, in most cases, fairly soft at the temperature for hot working and will hot work readily. This particular class of stainless steel does not differ from the ordinary carbon steel as far as its hot working is concerned with the exception that they are somewhat stiffer or harder due to their higher alloy content. They do not scale appreciably at their rolling temperatures due to the chromium content and as a result present any problem as far as hot working is concerned. It is necessary to slow cool most of this class of stainless steel after rolling to prevent cracking due to strains which are set up by air cooling. If the chromium content is over 20 per cent these higher chromium stainless steels are very susceptible to grain growth making them very brittle. The rolling temperature on these steels must be held to a lower temperature than normal to prevent this condition. The finished bar or coil must be made from as large a billet as is practical to insure enough hot working to adequately break down any large grain size which may have carried through from the ingot or the hot rolling operation on the ingot.

The second class of stainless steels (those which are not hardenable by heat treatment) are alloys of iron, chromium and nickel. These steels are very tough, have very high strength at elevated temperatures, and their metallurgical properties are affected by very slight differences in analysis. They are what are known as austenitic steel which means that they are non-magnetic, tough, and very ductile. By changing the chemical composition slightly it is possible that they will become partly austenitic and partly ferritic. The ferrite that forms in such a steel is considerably less tough, does not have the high temperature strength that the austenitic constituent does, and therefore when a condition of mixed austenite and ferrite is encountered, difficulty may be found upon hot rolling in that the two constituents which make up the steel are of quite dissimilar properties, one tough, ductile and of high strength at the rolling temperature, the other softer, less tough and decidedly weaker at the rolling temperature. This condition results in excessive tearing or cracking in the hot rolling operation. This condition, which may occur in the rolling of the chrome-nickel stainless steels, makes it absolutely necessary to closely control the analyses of these steels within relatively narrow limits. The tendency to this duplex structure is characteristic of the more highly alloyed stainless chrome-nickel steels, such as Type 310 which contains 25 per cent chrome and 20 per cent nickel. The rolling temperature also affects the amount of the weaker ferrite present so this rolling temperature must be closely controlled to minimize the occurrence of this weak phase in the higher alloy stainless steels. The rolling practice developed over a period of years by the companies manufacturing stainless steels in various forms has been the result of years of research and experience on these types of steel.

There are new types of stainless or modified stainless steels coming on the market and each new type presents problems of its own in the hot working operation. The tendency in recent years is to go higher and higher in alloy content to obtain steels resistant to attack by strong acid and other corrosive materials, and with the development of gas turbines for aircraft and other uses the stainless steels have been modified to give very high strength at elevated temperatures. This increased high temperature strength is achieved by taking a fairly standard stainless steel and adding other alloys, such as tungsten, molybdenum, cobalt, columbium, or others. By the use of these alloys, the stainless steel possesses strength at elevated temperatures which is nearly as high as carbon steel is at room temperature. This high temperature strength, of course, adds to the difficulty

in hot working because the steel is that much harder at the rolling temperature.

This paper has attempted to point out the highlights of the hot working of stainless steels as practiced in industry today. Each plant has its own peculiar practice and so this paper has been confined to the general practice which should be common to all manufacturers of stainless steel.

As mentioned before, stainless steel is a specialty item and its production is relatively small in comparison to the common steel production. It is, however, finding wider and wider acceptance in industry today and should continue to grow in use as more and more applications are found which can take advantage of its high strength, corrosion resistance, good appearance and high temperature strength.

DISCUSSION

PRESENTED BY

E. ALAN AUER, Assistant Foreman Roll Shop, Crucible Steel Co. of America, Syracuse, N. Y.

DOUGLAS GORMLY, Assistant Chief Metallurgist, Allegheny Ludlum Steel Corp., Dunkirk, N. Y.

J. LAURIE EDWARDS, Superintendent Bar Mills, Republic Steel Corp., Buffalo, N. Y.

I. H. MacPHERSON, Metallurgist, Atlas Steels, Ltd., Welland, Canada

J. H. JANSSEN, Assistant Chief Metallurgist, Wickwire Spencer Steel Division, Colorado Fuel and Iron Corp., Buffalo, N. Y.

E. W. MILLIGAN, Shift Foreman, Bloom Mill, Steel Co. of Canada, Ltd., Hamilton, Canada

F. A. LOCKE, Superintendent of Hot Work, Crucible Steel Co. of America, Syracuse, N. Y.

E. Alan Auer: I would like to ask at what point repeaters are first used, on the combined 14 and 10 in. mills; that is, when finishing about a ⅜ in. round on this unit, what size square or oval is first repeated, and are repeaters used continuously from this point on, down to the finished size?

Douglas Gormly: We have two coil mills, one of which rolls the small sizes, from ⅜ in. down, and the other a complete range of sizes in smaller lots. The former uses repeaters and the latter does not. We have used repeaters on large ovals in the 14 in. stands.

J. Laurie Edwards: Is it not a fact the reason you are rolling stainless steel bars on the older type Belgian mills is because your orders are so small? They can be rolled on a high speed mill, in fact they have been rolled on high speed rod mills.

Douglas Gormly: Yes, to a large extent you are right. An order which to us looks like a large order would be a relatively small order to the average carbon steel mill. I would think a typical carbon steel mill would ship as much in a day as the smaller stainless steel mills would ship in a month. At the present time, the production of small stainless steel bars does not warrant the use of a high speed mill. It is interesting to note the use of high speed looping mills for stainless wire and particularly large, high speed, continuous mills for stainless strip, both of which are being produced in increasing tonnages.

J. Laurie Edwards: Do you think it is absolutely necessary to have a huskier mill to roll stainless steel or manganese steel? Do you not think it can be done by lightening up the drafts and rolling it on the older mills? I am sure this was the case in the early days of the rolling of tool steels.

Douglas Gormly: Stainless can be rolled that way but the economic way is to increase the drafts, cut down the number of passes and thereby increase production and reduce costs.

J. Laurie Edwards: How large a round are you repeating?

Douglas Gormly: Seven-sixteenths in.

J. Laurie Edwards: Why do you not repeat larger sizes?

Douglas Gormly: The larger tonnages are in the small sizes. The amount rolled in larger sizes does not warrant the use of repeaters.

J. Laurie Edwards: I understand the larger sizes are made up of smaller items per size.

Douglas Gormly: Yes, the relatively large weight of small sizes is influenced by the amount of wire smaller than normal hot rolled sizes. Obviously, to make a given cold drawn product, the hot rolled material used will be as small as the cold drawn size and specified physicals will permit.

I. H. MacPherson: Mr. Gormly, you mentioned that sometimes when the chemical balance between chromium and nickel is unsuitable, a heat is produced which has a duplex microstructure, a mixture of delta ferrite and austenite. You also indicated that the high temperature properties of such a combination are inherently poor and that such a heat would be difficult to roll. In actual practice, what can be done about this condition? Must the heat be scrapped or diverted to large sizes, or is there any optimum rolling practice which will accommodate such heats?

Douglas Gormly: There really is not too much you can do. The trouble with the heat is most prominent in the cogging, or early reduction stage. We have found that once the heat is reduced to billets, the finishing operation presents no difficulty. The poor workability of these heats can be minimized by reducing to billet in several heatings and reductions, sometimes with grinds between reductions. If billets cannot be made in this manner, the heat must be scrapped. Obviously, the aim of the mill is to make heats with the proper chromium nickel balance.

J. H. Janssen: You were talking about a quarter-inch rod going to the 180 size. What would be the pickup in tensile when drawing the 50 per cent reduction from the rod to the finished size?

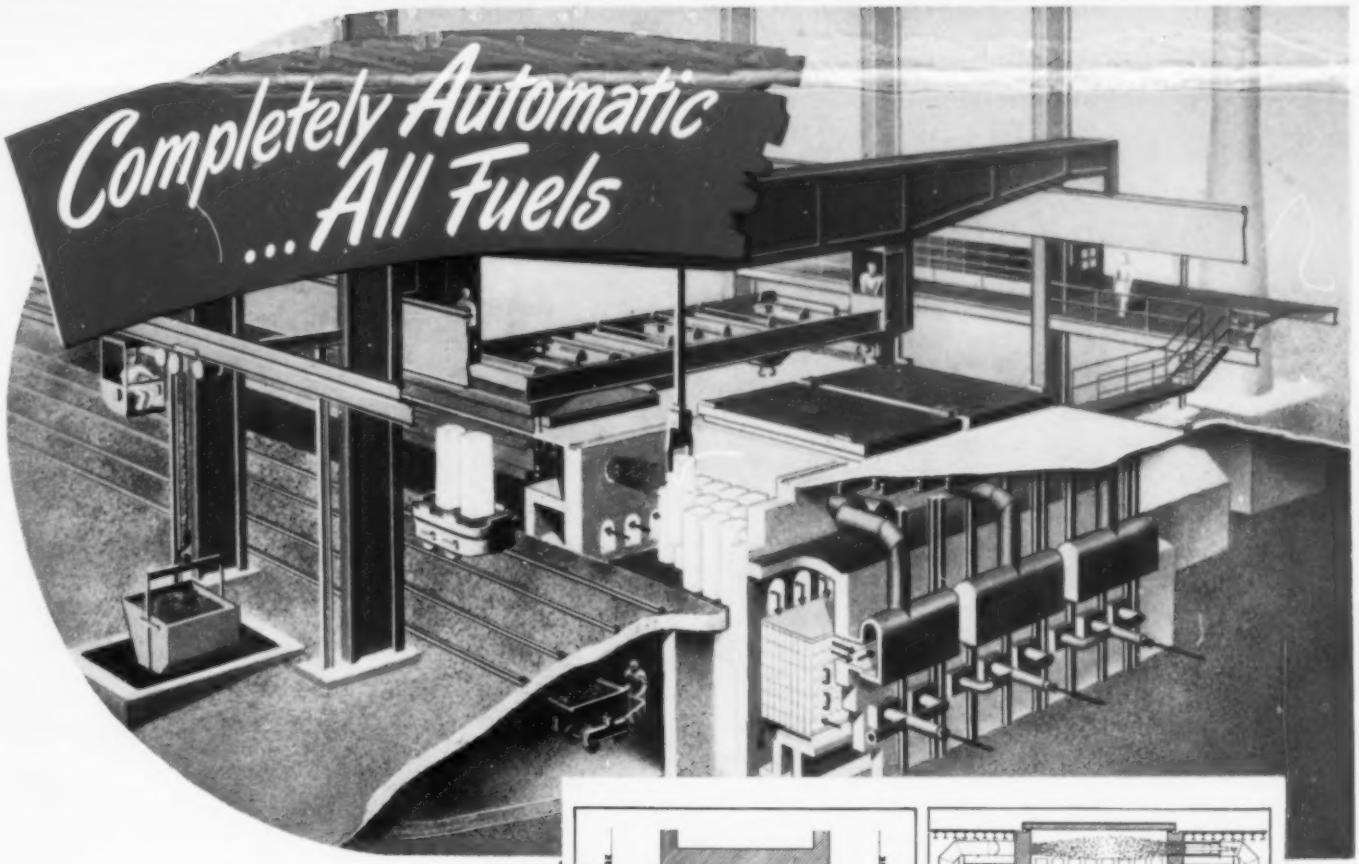
Douglas Gormly: The hot rolled annealed material has a tensile of about 105,000 psi and the finished material a tensile of about 200,000 psi or a pickup of 95,000 psi.

E. W. Milligan: After your breakdown to billets, do you pit-anneal them before reheating for finishing operation?

Douglas Gormly: Only those grades which air-harden sufficiently to cause straining or cracking in the billet grinding operation are annealed after the breakdown.

F. A. Locke: Do you roll cog both low and high silicon 310?

Douglas Gormly: Yes.



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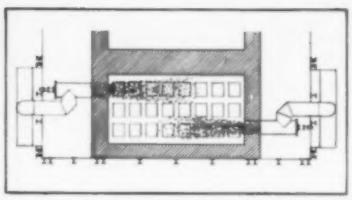
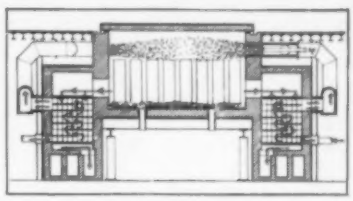


PLAN VIEW



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GIANT GEAR CUT

While Still on Drive

By E. C. DENNE
Manager Gear Department
United Engineering and Foundry Co.
Pittsburgh, Pa.

▲ When a gear becomes worn and needs to be recut, if it weighs a hundred and ninety tons, it is impractical to dismount it and ship it off to the manufacturer for repair. Last summer, the Carnegie-Illinois Steel Corp. had to repair a gear in the 96-in. plate mill of the steel company's South Chicago Works, which had been originally built by United Engineering and Foundry Co.

Designed to transmit approximately 20,000 hp at 10.1 rpm, the gear is one of a series of eleven, in a drive that has an overall length of 94 ft 6 in. and a width of about 24 ft. The fly wheel drive is activated by a 6000 hp motor having a speed of 365 rpm. Three mills take their power from this assembly.

To dismantle and ship the giant gear, reassemble it in the shop, recondition it there, return it to Chicago, and finally assemble it again in the drive where it belongs, would be a three-months undertaking. However, three months of down-time could not be permitted. There had to be some other way.

Figure 1 — The teeth on the gear were staggered, but the index wheel was designed for double the number of gear teeth so one side of all the gear teeth could be cut in one revolution.

After study and consultation between the staff and representatives of Carnegie-Illinois Steel Corp., it was decided to recut the big gear in its gear case on its own journals; and a procedure was agreed upon for which ten days was allowed.

The plan was to dismantle certain parts of the drive as seemed necessary, erect specially designed cutting equipment, recondition the pinion-contacting surfaces of the gear teeth, then take down the cutting equipment, reassemble the drive, and start rolling again, all within the allotted ten days.

In fact, the work progressed somewhat better than the schedule called for, though the actual down time was extended to fourteen days because it was decided, after the pinion-contacting side of the gear had been cut, that the other side, which makes contact with the mating idler gear, should also be recut. This side was in better condition and required less work, but did account for the difference in time on the completed job.

Because of the urgency for earliest possible completion, only one cut on each surface could be made, and it is remarkable that errors were kept well within practical limits. After the gear had been restored to use and had been

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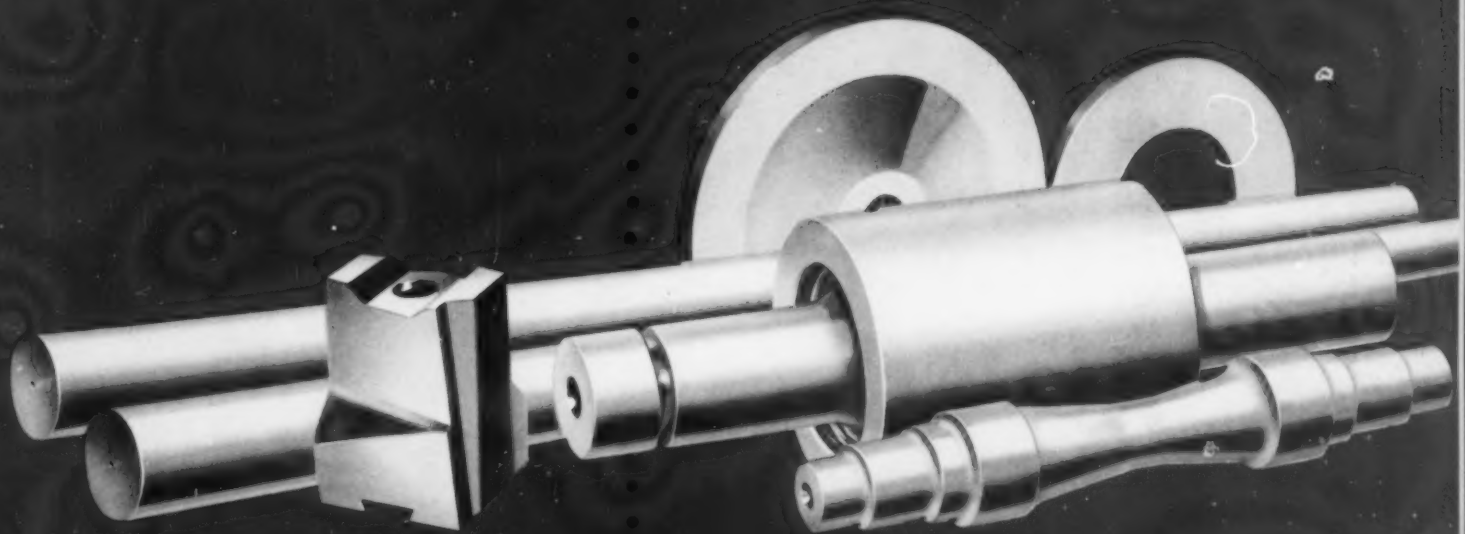

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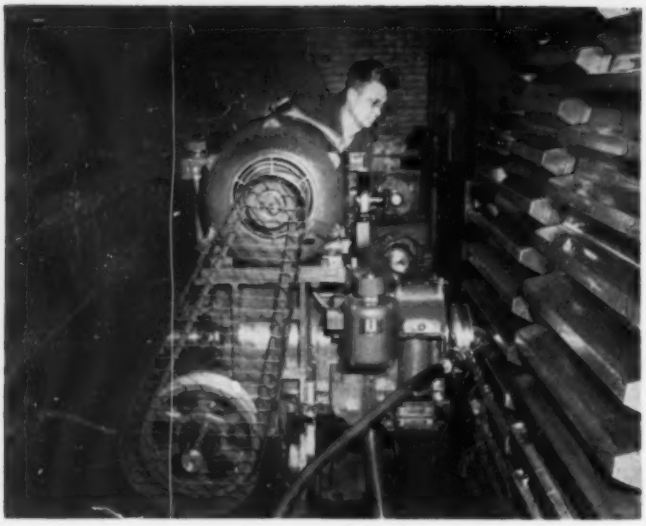

Figure 2 — The setup for cutting the gear is shown in this photograph.

Figure 3 — Hydraulic jacks were used to rotate the gear into position and it was then held by heavy set screws while each tooth was being cut.

rolling steel again for ten days, the cover was removed and a close inspection made. The gear teeth showed practically 100 per cent contact across the face, on the entire circumference, which was definite proof of a successful job.

In the operation, the great gear was rotated tooth by tooth during the work, by means of heavy hydraulic jacks, and held in place by heavy set screws while each tooth was being cut. Exact positioning was necessary, and was governed by aid of a large index wheel, 120 in. in diameter, with twice as many teeth as the gear itself. This wheel was so set that, as it turned, an indicator mounted on one side would tell the position of each gear tooth and also of the opposite stagger tooth. Precision in setting the indicator was necessary, and must allow, too for proper grinding of the gear cutter. The method adopted for doing this difficult and important job was original and unique and all who had a part in it are to be congratulated.

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"On several occasions, for some reason, these protectors failed to operate when they should have and the motor would have burned out except for the opening of the Fusetron fuses.

"The company's plant engineer was so impressed by the way these Fusetron fuses prevented damage to the motors and saved the company time and money that he authorized us to install Fusetron fuses throughout the entire plant."

Howard Firestone. Owner
FIRESTONE ELECTRIC COMPANY,
Salem, Ohio

Facts About FUSETRON Dual-Element Fuses

The fuse link element opens on short-circuit — the thermal cutout element protects on overloads — the result, a fuse with tremendous time-lag and much less electrical resistance.

They have the same degree of Underwriters' Laboratories approval for both motor-running and circuit protection as the most expensive devices made.

Made to the same dimensions as ordinary fuses — fit all standard fuse holders.

Obtainable in all sizes from 1/10 to 600 ampere, both 250 and 600 volt types. Also in plug types for 125 volt circuits.

Their cost is surprinsingly low.

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Fusetron DUAL-ELEMENT Fuses

with their

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1. Protect against short-circuits.
2. Protect against needless blows caused by harmless overloads.
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Don't risk such losses — protect yourself by installing a FUSETRON dual-element fuse in every set of fuse clips throughout the entire electrical system.

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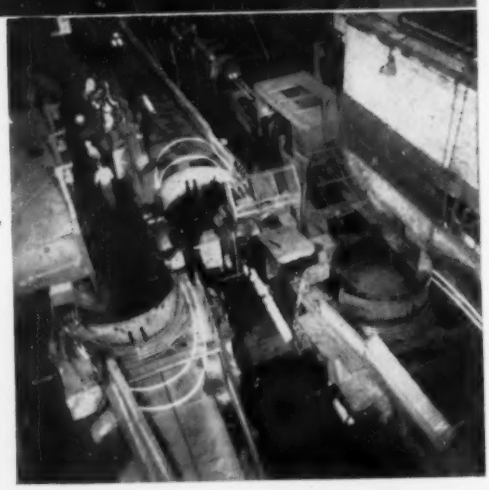
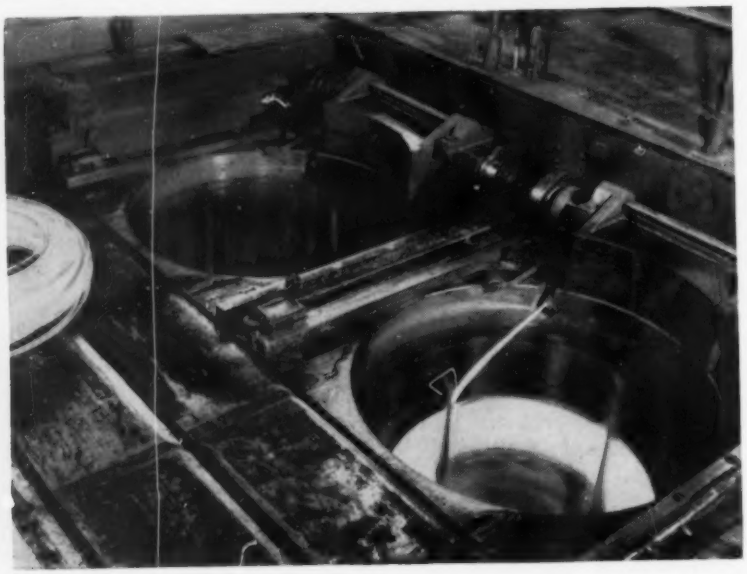
Rolls & Guides



View of 14"-12"-10" Mild Steel Rod Mill

Pouring Reels & Apron Conveyor



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Mills, Plate
Mills, Rod
Mills, Sheet
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Mills, Strip (Hot) & Skelp
Mills, Vertical Edging
Mills, Ring
Planers, Plate
Pilers, Sheet & Plate
Pushers, Furnace
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Midget Triploc *Series* **Same construction features as Triploc except for much smaller outside diameter of plug shell—only 1¼". Interchangeable and reversible contact units—2, 3 and 4 pole—are of the flat blade type. Rated 10 amperes, 250 volts; 15 amperes, 125 volts.**

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Fusible Plug

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General Purpose *Series* **Available with cast metal housings in many types for circuit breaking and disconnect service. 30 amperes, 125 volts DC, 250 volt AC—1, 2, 3, 4, 5 and 6 pole. 60 amperes, 250 and 600 volts—3, 4 and 5 pole. 100 ampere, 250 and 600 volts—2, 3 and 4 pole. Also many special types, fusible and fuseless, for varied applications.**

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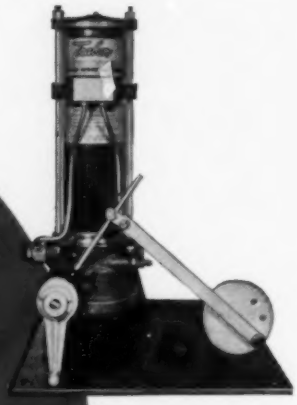

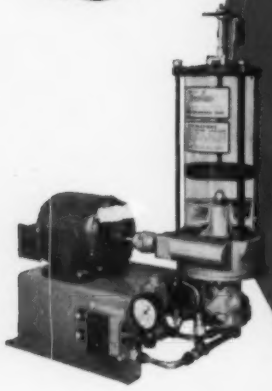

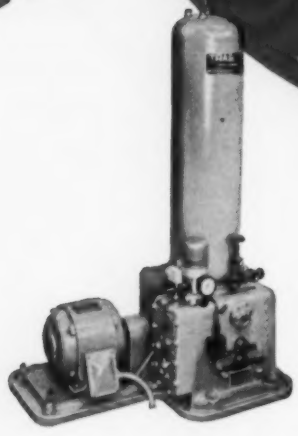

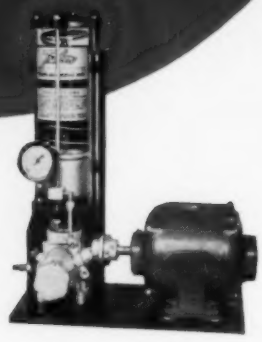

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Date-line Diary...

December 1

▲ Liquidation of American Arch Co., a Delaware Corporation, and American Arch Co., Inc., New York, was voted by stockholders at a special meeting.

▲ Struthers Iron and Steel Co. announced that their "Anna" blast furnace at Struthers, Ohio, will be blown in in the near future.

▲ John L. Lewis ordered a three-day week for coal miners effective December 5. The men will dig on Monday, Tuesday and Wednesday.

▲ Reconstruction Finance Corp. reduced its selling price for grade A tin 2¢ a lb to 83¢, New York, for spot delivery.

December 2

▲ Tin prices were again cut by Reconstruction Finance Corp. to 81¢ per lb, New York.

December 4

▲ No. 2 blast furnace at the Midland, Pa. plant of Crucible Steel Co. was blown in, following a six-month shutdown for relining.

December 5

▲ Federal Trade Commission attorneys disagreed on whether the commission should accept a steel industry proposal to end the government anti-trust suit against the industry. This proposal promises f.o.b. mill prices, no agreement on base prices, and no cooperation in compiling freight rates, in return for permission to absorb freight where the result will not lessen competition.

▲ Value of new construction in 1949 is practically certain to set a new record, according to the Departments of Labor and Commerce. The total for 11 months is $17,700,000,000.

▲ Based on reports from companies having 94 per cent of the steel capacity of the industry, the operating rate of the industry is scheduled to be 91.7 per cent of capacity for the week beginning December 5.

▲ Admiral Ben Moreell, president and chairman of the board, Jones & Laughlin Steel Corp. said that, "in view of increased costs for raw materials, services and labor, it becomes clear that steel prices must be increased."

▲ The United Brick and Clay Workers of America (AFL) entered into a new contract with 14 fire brick manufacturers in Pennsylvania, Ohio, Kentucky and Missouri. The contract calls for an enlarged contributory insurance program and a company-financed pension plan.

December 6

▲ Total employment during November recovered the losses arising from the disputes in steel and coal, according to the Department of Commerce. Employment rose to 59,518,000 by mid-November.

▲ The Supreme Court ruled that a company with a valid closed shop contract cannot be held guilty of an unfair labor practice when, at the union's request, it discharges workers trying to form a rival union.

December 7

▲ Republic Steel Corp. management looks for excellent steel business through most of 1950, according to J. M. Schlendorf, vice-president.

▲ U. S. exports in October exceeded imports by only $289,000,000, the smallest balance since the shipping strike in November, 1949. October exports declined to $848,000,000.

▲ John L. Lewis signed new contracts with a number of Kentucky coal operators producing about 2,500,000 tons per year. The agreement calls for 95¢ per day wage increase and royalty payments to the UMW welfare fund of 35¢ a ton.

▲ Motor vehicle demand over the next five years was estimated at 5,000,000-6,000,000 units per year by W. A. Williams, of Ford Motor Co.

December 8

▲ Aluminum Co. of America signed a pension-insurance pact with the CIO Steelworkers, ending a 52 day strike. The settlement closely follows the steel agreements.

December 9

▲ Engineering construction contracts during the week ending December 8 were $902,000,000, highest week in 1949.

December 10

▲ Eastern railroads are studying possible rate cuts to meet truck competition in hauling iron and steel. The study covers the area north of the Ohio River and east of the Mississippi. At present, truck rates in this area are approximately 10-25 per cent lower than rail rates.

▲ Hard coal operators and the United Mine Workers failed to agree on a new wage agreement during the first week of negotiations. Operators were set in opposition to UMW requests for a wage increase of about 95¢ a day and royalty payments of 40¢ a ton to the union's welfare fund.

December 12

▲ Mahoning Valley Steel Co. raised its steel prices $10 per ton, following the lead of Sharon Steel Corp., who raised semi-finished steel by $5.00 a ton, and Follansbee Steel Corp., who recently increased prices of high-silicon electrical sheets by $35.00 a ton.

▲ Price increases of 14 and 15¢ per bbl on Pennsylvania crude oil were announced by the Joseph Seep Purchasing Agency, an affiliate of South Penn Oil Co.

▲ Electric utilities will report total 1949 earnings of about $778,000,000, the largest in the industry's history.

▲ Based on reports from companies having 94 per cent of the capacity of the industry, the operating rate of the steel industry is scheduled to be 94.1 per cent of capacity for the week beginning December 12.

December 13

▲ Personal income during October dropped to an annual rate $208,400,000,000, due to the steel and coal strikes.

▲ New freight cars delivered to American railroads totaled 89,232 for the first 11 months of 1949. November deliveries totaled 4376, compared with 4532 in October. The total for 1949 is estimated at about 93,350. Passenger car deliveries for 1949 will total about 950.

December 14

▲ Recovering sharply from effects of the strike, steel production for November totaled 4,145,294 tons. Production for the first 11 months of 1949 totaled 70,080,776 tons.

▲ Output of electricity last week rose to 5,881,000,000 kwhr, the highest in history.

December 15

▲ Thomas Steel Co. announced contract awards for a modernization program at its plant at Warren, Ohio. The program includes a new three-stand cold reduction mill.

▲ Part of the construction work was inaugurated on the ECA steel mill project in Lorraine, France. This project includes an 80-in. hot strip mill, with cold mills and finishing equipment, to be followed by primary iron and steel producing facilities.

▲ Colorado Fuel and Iron Corp. announced a $3,000,000 expansion and improvement program at its Pueblo, Colo. plant. The project will include rail-slitting and rerolling equipment.

December 16

▲ Subsidiaries of United States Steel Corp. announced new prices for most of its steel products, consisting of changes in base prices and in extra charges, the new prices combine to give an increase of about $4.00 per ton (or about 4 per cent) on the overall average selling price.

▲ In Washington, Senator O'Mahoney asked other steel producers not to follow the move to boost prices. CIO officials asked Congress to investigate steel prices. B. F. Fairless stated that United States Steel Corp. would welcome the opportunity to present facts and figures upon which the price increases were based.

▲ No. 1 heavy melting scrap sold in Pittsburgh for $31.00 per ton, a drop of $1.00.

December 17

▲ Youngstown Sheet and Tube Co. stated that its steel prices will be advanced shortly, due to rising costs of materials, services and labor.

December 19

▲ Lukens Steel Co. announced it will shut down its 206-in. plate mill for 90 days to complete electrification of the mill drive. The new drive will consist of twin 4000-hp motors, and the project will cost over $2,000,000.

▲ Directors of Steel Co. of Canada, Ltd. have approved a proposal to split their common and preferred stock shares on a five-for-one basis.

▲ Based on reports from companies having 94 per cent of the capacity of the industry, the operating rate of the steel industry is scheduled to be 94.5 per cent of capacity for the week beginning December 19.

December 20

▲ Armco Steel Corp. announced it has licensed its patented continuous galvanizing process to Inland Steel Co.

▲ Republic Steel Corp. and Armco Steel Corp. announced steel price boosts averaging about $4.00 per ton.

▲ Oil consumption during 1949 has run slightly below the peak level of 1949. Average daily demand has been placed at 6,105,000 barrels.

▲ Youngstown Sheet and Tube Co. announced an extra year-end dividend of $1.00 per share of common stock.

▲ The new 30-in. strip mill installation at Alan Wood Steel Co. started test runs. Regular operations are expected in January.

December 21

▲ Steel price increases averaging about $4.00 per ton were announced by four steel companies: Jones and Laughlin Steel Corp., Allegheny Ludlum Steel Corp., Pittsburgh Steel Co., and Wheeling Steel Corp.

▲ General Electric Co. sales for 1949 will be close to the record 1948 volume, but profits will be lower, according to C. E. Wilson, president. G.E. has enough orders for large motors and generators to keep those divisions operating at capacity for two years.

December 22

▲ National Tube Co. expects operations of its new electric weld pipe mill and its new high-pressure boiler plant at McKeesport, Pa. to begin by next spring.

▲ According to the American Iron and Steel Institute, the steel industry's payroll for the first nine months of 1949 was higher than ever before for a similar period, being estimated at $1,670,000,000. Average hourly payments to wage earners rose to $1.712 per hour in September, when the work-week averaged 36.8 hours and employment was estimated at 600,200.

▲ Eugene G. Grace, chairman of Bethlehem Steel Corp., stated that the company's new pension plan will cost $7,500,000-$10,000,000 per year ($2,000,000-$2,500,000 more than for their previous pension plan) for the next five years, plus added costs for insurance benefits, with a non-recurring cost in 1950 of as much as $10,000,000.

December 23

▲ Youngstown Sheet and Tube Co. raised its steel prices an average of about $4.00 per ton.

▲ Lukens Steel Co. advanced its base price of carbon steel plates $2.00 per ton. No change was made in alloy steel plate.

▲ No. 1 heavy melting scrap sold in Pittsburgh for $30.00 per ton, $1.00 under the previous price.

▲ Base prices and extras for most of Granite City Steel Co. products were adjusted so as to result in an average increase of about $4.00 per ton.

▲ Kaiser Steel Corp. announced increases in steel prices averaging approximately 4 per cent.

December 24

▲ The Interstate Commerce Commission directed coal producers not to fill requirements of other customers until minimum needs of railroads are met.

December 26

▲ Indications are that the American Federation of Labor will seek a further increase in wages of about 10¢ per hr in 1950.

December 27

▲ Carnegie-Illinois Steel Corp. announced acquisition of a 3800 acre tract of land on the Delaware River about 30 miles northeast of Philadelphia, Pa.

▲ Based on reports from companies having 94 per cent of the capacity of the industry, the operating rate of the steel industry is scheduled to be 93.1 per cent of capacity for the week beginning December 26.

December 28

▲ Empire Steel Corp., owned by Studebaker Corp. since December, 1947, was sold to Rema Co. of Dover, Ohio. Rema is a new company headed by officials of Empire and Reeves Steel Corp.

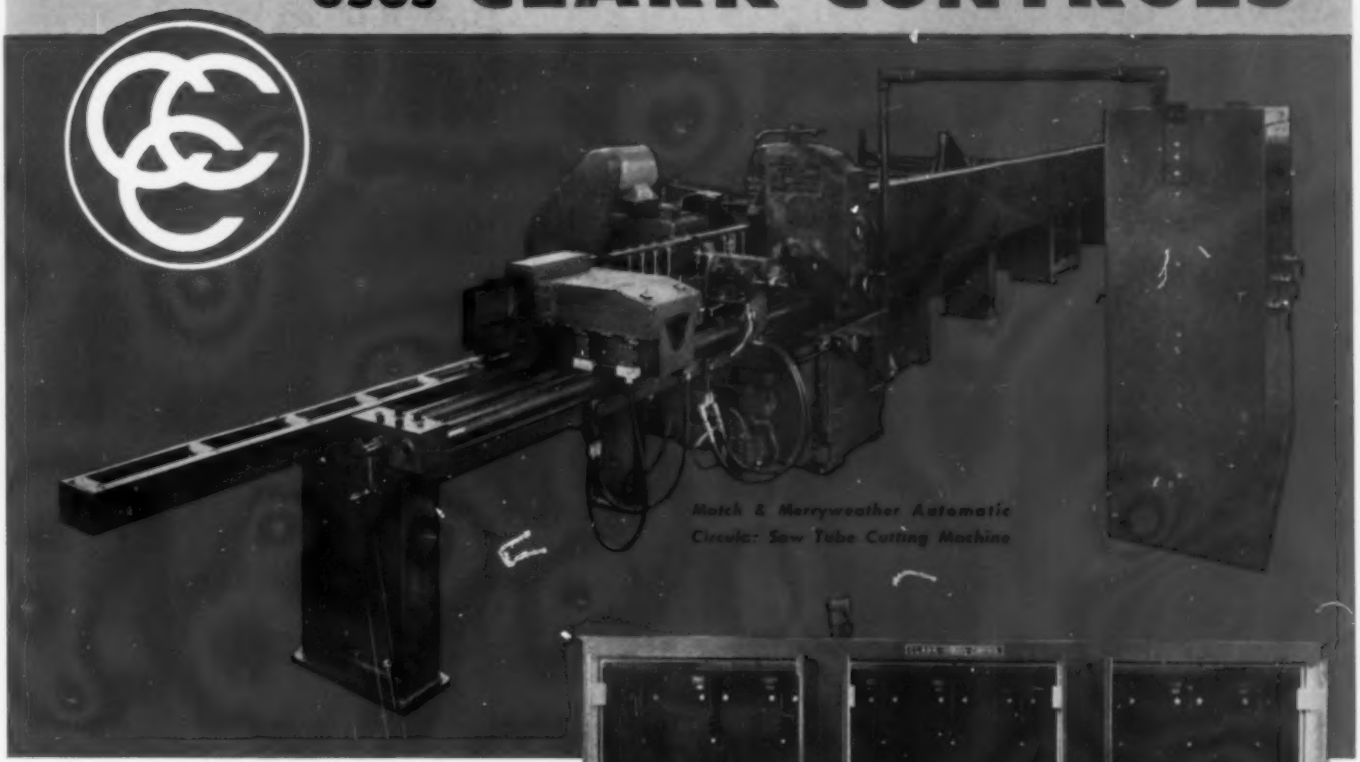
▲ Estimated bookings of fabricated structural steel for November totaled 101,583 tons, according to the American Institute of Steel Construction. The total of 11 months of 1949 was 1,306,370 tons, as against 1,796,216 tons for the first 11 months of 1948.

December 29

▲ The price of zinc was raised a quarter of a cent to 10¢ per lb, East St. Louis.

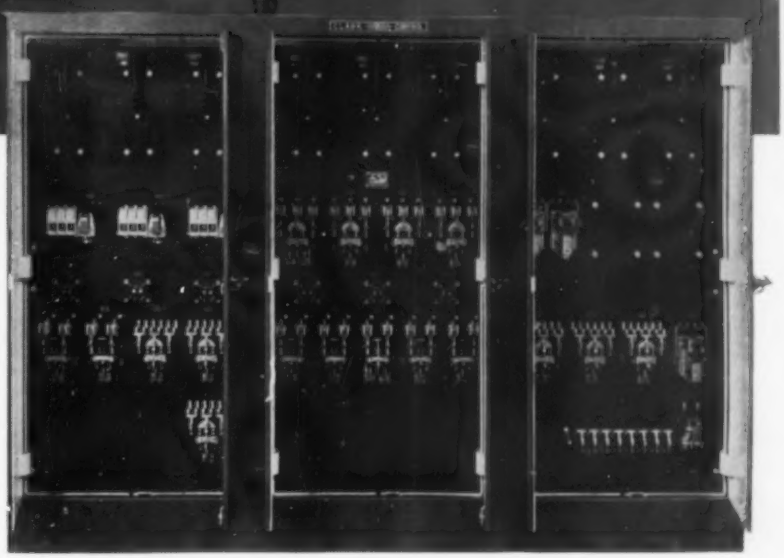
▲ Southern coal producers urged the National Labor Relations Board to seek a court injunction against the shortened work week and other activities of the United Mine Workers, charging them with engaging in unfair labor practices.

STEEL MILL AUTOMATIC CIRCULAR SAW uses CLARK CONTROLS



This Motch & Merryweather Automatic Circular Sawing machine–installed in a Mid-West steel plant–rapidly cuts square welded tubing into accurate lengths.

The loading, stock feed, cut-off to length, and ejection of finished pieces is automatic. The entire operation functions with CLARK ENGINEERED CONTROL, thus eliminating operator fatigue, and materially reducing production time.



CLARK CONTROL PANEL for Motch & Merryweather Circular Saw

This machine handles 24-foot stock lengths in multiple. The sawing area is 4 x 12 inches with cut off lengths up to 8 feet long. Five pieces of 2½ inch square tubing are cut, ready for shipping every 90 seconds.

The 7½ HP saw motor, 2 HP Hydraulic Pump motor, ¼ HP coolant motor, 7½ HP walking beam motor, the 3 HP stock feed motor, and the 1 HP take-off motor are all controlled by CLARK HEAVY DUTY Bulletin 7700 and Bulletin 7400 contactors, and overload protection is supplied by Bulletin 7322 Thermal Overload Relays. All control apparatus is enclosed in neat floor mounted vault type cabinets.

Where heavy duty operation is required, there you'll find CLARK CONTROL.

THE CLARK CONTROLLER CO.

ENGINEERED ELECTRICAL CONTROL • 1146 EAST 152ND STREET, CLEVELAND 10, OHIO

Is PHYSICAL STRENGTH your magnet problem?

Mills agree that skull-cracking subjects a magnet to the roughest of service. Cautioning crane operators to "take it easy" is sage but frequently impractical advice.

Why not fit your magnet to the job when you buy?

Ohio *basket-type* magnets are specially constructed to withstand hard knocks. "Fenders" project beyond magnet diameter . . . stave off and protect against damaging blows.

For extra magnet life in rough service, install Ohio *basket-type* magnets. Write today to Ohio—25 years a leader in *magnetic materials handling.*

Use "basket" construction for rough service

OHIO PROTECTO-WELD MAGNET is welded *on top,* where weld cannot be dented in. Sizes include 39, 46, 55 and 65-inch diameters. Ohio also builds magnet control equipment.

THE OHIO ELECTRIC MFG. CO. • 5900 MAURICE AVENUE • CLEVELAND 4, OHIO

ohio MAGNETS

Industry News...

CARNEGIE-ILLINOIS ACQUIRES LAND TRACT SUITABLE FOR FUTURE SEABOARD PLANT

▲ Carnegie-Illinois Steel Corp. announced recently that it is acquiring a 3,800-acre tract of land, located on the Delaware River in Falls Township, Pa., about 30 miles northeast of Philadelphia.

It was immediately emphasized by the steel company management that while this land was acquired for possible future use as a site of an eastern seaboard steel mill, the building of such a mill has not yet been authorized.

The initial authorization for such a project would have to be many millions of dollars.

It would take nearly one billion dollars to duplicate the facilities at the Homestead works of Carnegie-Illinois, and around $500 million to set up another Edgar Thomson works in eastern Pennsylvania.

When started, the plant is expected to be a progressive development. Some of United States Steel's customers now served by the Pittsburgh area mills would obtain their steel from the new project, although it was also pointed out that the growth in population and exports might permit avoidance of such diversion.

The location will permit the docking of ocean-going ore boats which will bring iron ore from the new US Steel ore development in Venezuela.

This ore is the key to the eastern seaboard plant, and the necessity of huge investments in South America will add to the cost of the project. The Venezuelan ore is located on hills in virtually inaccessible parts of that South American country, and while economical open pit mining of ore is possible, roads must be built, a railroad constructed and USSteel must establish docks and build ore boats before the ore in quantity can be brought north.

GRANITE CITY STEEL COMPLETES MODERNIZATION

Granite City Steel Co., Granite City, Ill., closed its last old hand mill in a ceremony at the plant November 30, 1949, which also saluted completion of a 15-year, $20,000,000 modernization program. Three members of the old hand mill crew, Mayor Joseph M. Darst, St. Louis, Mo., John N. Marshall, board chairman, and Mayor Leonard Davis, Granite City, Ill., are shown inspecting the last sheet of steel to come from the old mill.

Granite City in its modernization program has installed a 90-in. continuous hot strip mill, a 56-in. continuous 4-stand tandem cold reduction unit, continuous pickling line, 13 gas heated radiant tube annealing furnaces, skin pass units for temper shearing and slitting and classifying equipment for tin plate. (A major portion of the modernization program was described in an article entitled, "Granite City Steel Company," IRON AND STEEL ENGINEER, July 1940.)

ARMCO PLANT SHIPS OVER 1 MILLION TONS

▲ More than one million tons of steel were shipped from the East works plant of Armco Steel Corp. during 1949. The million-ton figure was substantially greater than the old record which was established last year.

FOUNDRY FIRM EXPANDS CASTING FACILITIES

▲ Pittsburgh Mill Steel Co., Inc., announced the acquisition of two large industrial plants in the Philadelphia-Baltimore areas. The two purchases involve a total of 35 buildings on approximately 25 acres of land, making available about 272,000 sq ft of industrial space under cover. Both plants have sidings and are serviced by two major railroads; they are favored by their proximity to dock facilities.

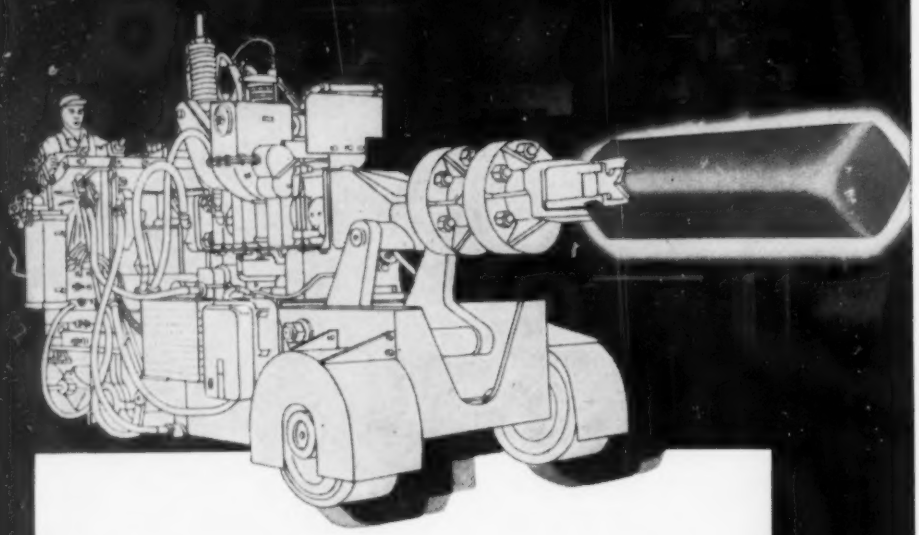
The Baltimore plant, well known in that area, has a magnesium castings division designed by the Anaconda Copper Co. during the war. In addition, there is a main foundry division completely equipped for the production of gray iron castings and soil pipe. The plant normally employs about 600 men.

Of particular interest in the Baltimore plant is a complete spectrograph, X-ray and testing laboratory of the most modern design.

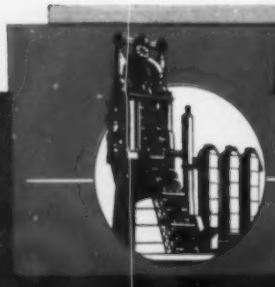
Both plants have a wide variety of equipment, including heat treating furnaces, machine shops, light and heavy cranes, and adequate floor space.

The Crum Lynne plant, adjacent to the Philadelphia area, has an elec-

deft*



* deft best describes a BROSIUS Auto Floor Manipulator at work in the forge shop. Deftly and quickly it draws or charges—moves with independent facility across the floor—raises and lowers and rotates the forging blank under hammer or press. Each unit has sturdiness and sensible engineering for which BROSIUS steel mill and blast furnace equipment is well known. BROSIUS manipulators will bring to your forge shop added safety, added speed, added economy —you should be using them. Write to us.



Edgar E. BROSIUS Company Inc.

SHARPSBURG • PITTSBURGH 15, PA.

tric melt division for the production of carbon and alloy steel castings, or ingots. It is also equipped to produce specialty gray iron castings in the foundry. When the plant is in full production approximately 200 men will be employed.

CANADIAN WELDING PLANT IS ESTABLISHED

▲ Establishment of the Nelson Stud Welding Co. of Canada, Ltd., with manufacturing facilities in Toronto, has been announced by Nelson Stud Welding division of Morton Gregory Corp. and its recently appointed Canadian distributors, the Rudel Machinery Co., Ltd.

J&L SUBSIDIARY BUYS CONTAINER PLANTS

▲ The American Can Co. announced the sale of two of the company's manufacturing plants at Toledo, Ohio, and Atlanta, Ga., respectively, to the J. & L. Steel Barrel Co.

Through the transaction the purchasing company, wholly-owned subsidiary of Jones & Laughlin Steel Corp., of Pittsburgh, will assume the galvanized ware and heavy steel container business of the can manufacturing firm.

RYERSON COMPLETES BUILDING ADDITION

Construction of a large brick and steel addition to the Chicago plant of Joseph T. Ryerson & Son, Inc., steel distributors, for which ground was broken in November, 1948, has been completed. The new building provides approximately 118,000 sq ft of plant and office space. It is located at 15th and Rockwell Streets, Chicago, Ill., and forms a part of what is known as the north unit of the company's six-block long plant. The building also extends east along 15th Street from Rockwell Street to the Pennsylvania Railroad, a distance of 470 ft. Construction includes a two-story office building in which the offices of the firm's concrete reinforcing bar division are now located.

The Complete Buy . . .

FOR ALL TYPES OF HEAT TREATING

No wonder F.E.I. heat treating performance is in the limelight. From coast to coast and abroad, plants report greatly increased output, improved metallurgical quality and lowered cost with F.E.I. furnaces and equipment. More than 30 years experience is back of F.E.I.'s Direct Fired Combustion System, utilizing patented burners, eductors, and fully automatic controls. No costly stacks are required.

Planned Construction . . . Insured Production

Whatever your problem—annealing, galvanizing, any form of heat treating—consult Furnace Engineers about improving YOUR plant's performance.

Write for This Bulletin

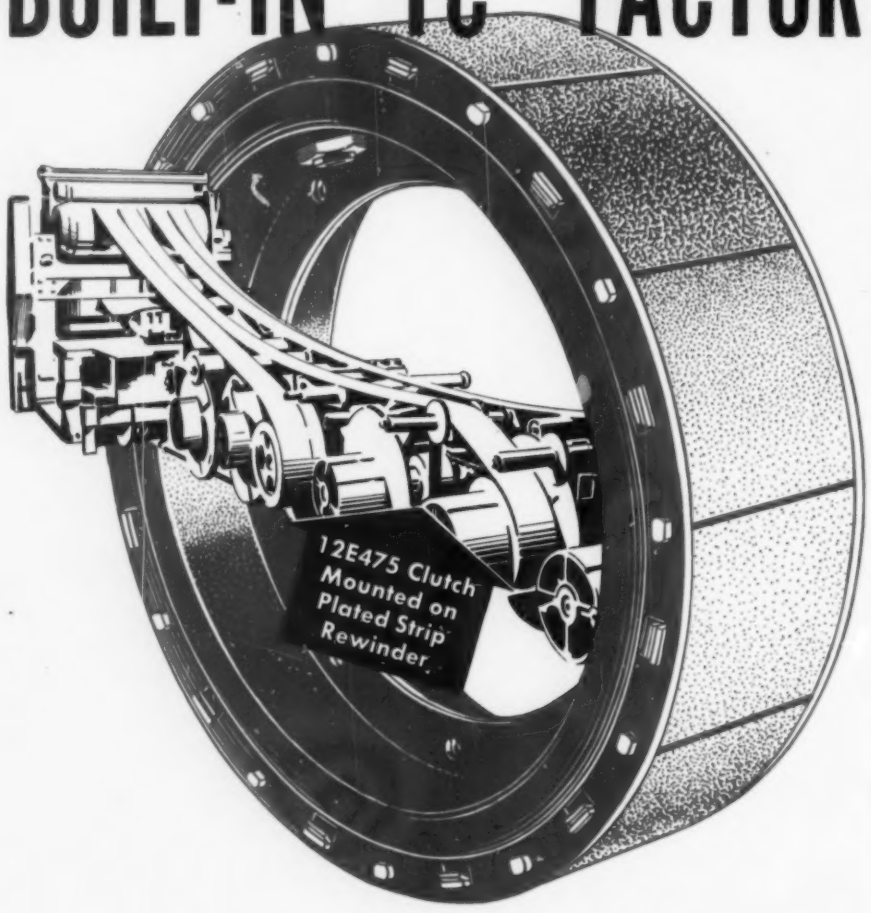
It tells about F.E.I. service . . . complete from plan to production.

F E I *Furnace Engineers, Inc.*

F. E. I. Building • 1551 West Liberty Avenue • Pittsburgh 16, Pa.

FAWICK AIRFLEX CLUTCHES HAVE A

BUILT-IN TC* FACTOR



*TENSION CONTROL for Strip Coil Winding

Just about everything desired for tension control of strip coil winding is built right into Fawick Type E Clutches. These rugged precision-built units have automatic self-adjustment to compensate for operating wear, providing coil winding machines with high efficiency operation and long maintenance-free life under the heaviest use.

Simple variation of the applied operating pressure produces any specific tension desired for smoother machine operation and perfect winding of strip coils.

For complete engineering information on Fawick Clutches, write to the Home Office, Cleveland, Ohio, for Bulletin 300.

All desirable clutch characteristics are built into Fawick Airflex units

FAWICK Airflex CO., INC.
9919 CLINTON ROAD CLEVELAND 11, OHIO

The Toledo and Atlanta plants are the only two of the more than 60 operated by the can company in this country, Canada and Hawaii which specialize in the fabrication of heavy-gage and galvanized metals. All other facilities are concentrated primarily on high speed automatic production of light-gage metal cans and fibre containers.

Agreements have been signed by J & L Steel Barrel Co., and the Fruehauf Trailer Co. for the sale of the latter company's plant on Chrysler Road in the Fairfax district of Kansas City, Kan.

MAINTENANCE DIVISION HAS SAFETY RECORD

▲ A new first in safety was established recently at South works of Carnegie-Illinois Steel Corp., a U. S. Steel subsidiary, when the plant's maintenance division employing nearly 2500 men worked two million man hours without a lost-time accident for the second time in the last 12 months.

This record which is particularly noteworthy because of the multiplicity of occupations involved, dates back to April 21, 1949, when the division's last lost-time accident occurred. The maintenance division passed the two million man-hour mark for the first time just a year ago by piling up 2,145,555 hours in a 168-day period.

RETIRED EXECUTIVES FORM MANAGEMENT TEAM

▲ A group of retired executives from the International Harvester Co. has been organized into a management team by one of their group, John Morrow, Jr., for industrial administration and analyses. These men who were not content to retire and loaf have thus made their talents available to industry to act as counselors for analyzing and correcting the numerous troubles that come up in industrial operations.

The group is composed of engineers, technicians and specialists who have an average of nearly 35 years service with the International Harvester Co. and they thus offer a pool of broad and varied experience. The men offer service in production development and design, plant location,

sources of supply, manufacture, inventory control, product distribution, research, transportation and traffic, blast furnace problems, steel mill layout, open hearth furnaces, blooming and finishing mills, and by-product coke ovens.

Of the fourteen men involved in the group, four are well known in the steel industry. These include W. E. Brewster, who was general superintendent of the Wisconsin Steel Co.; J. H. Dillon, formerly chief engineer of the Wisconsin Steel Co.; E. L. Ramsey, formerly open hearth superintendent; and L. B. Robertson, who was general superintendent of Wisconsin.

ARMCO LICENSES ITS ZINC COATING PROCESS

▲ A license to use its patented process for the continuous coating of flat-rolled sheet and strip steel in a bath of molten zinc has been granted to the Inland Steel Co. by Armco Steel Corp.

Coated sheets produced by this process can be severely formed or drawn without flaking or peeling of the zinc. It has revolutionized the manufacture of many galvanized products which previously had to be formed from uncoated steel and dipped in a bath of molten zinc after the forming operations. Such products can be formed directly from galvanized sheets made by the process with resultant savings in cost.

In 1936 Armco built the first continuous coating unit in its Butler, Pa., plant. Encouraged by the success of the pilot plant, Armco added three units, investing a total of approximately $5,000,000 in them.

Patents covering the process, granted to Tadeuz Sendzimir in 1938 and 1940 are controlled by Armco.

This continuous method of coating steel is radically different from standard galvanizing methods by which steel sheets are simply passed through a bath of molten zinc.

Under the process, cleaned steel strip enters a long furnace with controlled atmosphere consisting mostly of a mixture of hydrogen and nitrogen, with air essentially excluded. In the furnace the surface of the strip is made ready to receive the zinc coating and the steel is also annealed and softened.

Armco Steel Corp. recently announced it had decided to permit other companies to use the process under license arrangement.

NEW INSTRUMENT FOR TIN COATING OPERATION

▲ More uniformly coated electrolytic tinplate is obtained by using a new instrument developed at the research laboratory of Carnegie-Illinois Steel Corp. This meter, which continuously indicates and records tin coating thickness on steel strip during the plating operation, is now in regular use on all "Ferrostan" electrolytic tinning lines of United States Steel.

The new coating thickness meter operates entirely independently of other control instruments on the lines. Its function is to combine the electrical values of plating current, strip speed, strip width and plating efficiency in a precision circuit employing a self-balancing potentiometer to indicate and record thickness. For the convenience of the operator the instrument is calibrated in pounds per base box.

Formerly, the weight of coating was tested by chemical means from sample sheets selected at intervals from the lines.

Now, when changing from one ordered thickness of coating to another, the operator is not required to read a battery of meters and refer the readings to a chart. Instead, he adjusts the plating control dials until the plating thickness meter indicates the specific coating weight. Since the instrument provides a continuous indication of coating weight, any variation in plating thickness is indicated at once.

Provision can be made for the instrument to operate an alarm when the coating weight deviates from the specified value. Also, if desired, the equipment may be set readily to control coating weight.

Reference potentials which actuate the meter are received from a tachometer generator, whose electrical output is directly proportional to the strip speed, and from a shunt or the equivalent in the plating-current bus, which provides a potential directly proportional to the total plating current. Thus potentials that are always proportional to strip speed and total

EF
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BRIGHT ANNEALING AND NORMALIZING STEEL STRIP *Continuously*

● EF continuous annealing and normalizing furnaces subject the entire length of the coil to exactly the same time and temperature cycle, producing extreme uniformity of grain size, resulting in superior qualities for deep drawing.

These furnaces shorten the annealing and normalizing cycle – and reduce the tonnage of material in process. Tension on the strip, the speed of travel and the atmosphere in the furnace are accurately controlled, producing the exactly desired surface finish and physicals – day after day. Capacities to meet any requirement.

A SIZE AND TYPE OF FURNACE FOR EVERY PROCESS PRODUCT OR PRODUCTION

THE ELECTRIC FURNACE CO.
GAS FIRED, OIL FIRED AND ELECTRIC FURNACES
Salem - Ohio

plating current, respectively, are supplied to the meter continuously.

Since the quantity of tin deposited per unit area on the strip is a function of plating-current density, plating time and the efficiency of the plating bath, provisions were made to compensate for variations in these factors. The strip-width compensating potentiometer is calibrated to cover material 18 to 34 in. wide. The strip-width adjusting dial is calibrated in inches and can be set readily within plus or minus $\frac{1}{16}$ in.

Another potentiometer compensates for plating efficiency variations. Its indicating dial is calibrated in per cent and covers a range of 84 to 100 per cent plating efficiency.

The potentiometers and all resistors are contained in a steel cabinet mounted above and attached to the plating thickness meter.

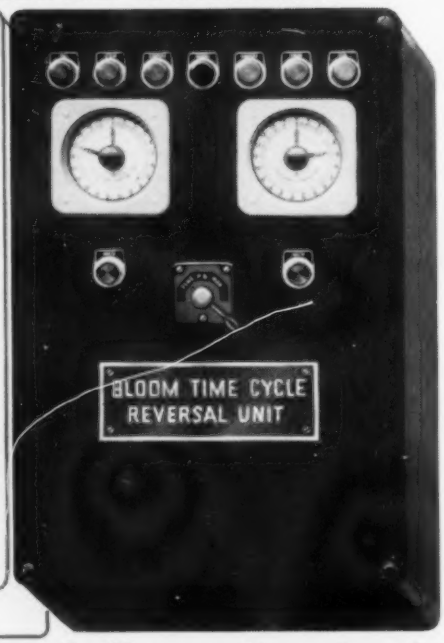
Following installation and calibration of the original plating thickness meter approximately 80 tests were made over a 10-day period of normal operation. These tests covered electrolytic tinplate production ranging from 0.25 to 0.75 lb per base box. In each test chemical determinations of coating weight were compared with indications on the plating thickness meter. The meter was found to indicate coating weights as accurately as the chemical method.

Use of the meter permits more accurate maintenance of plating conditions, thereby preventing excess plating of certain products and assuring against coating deficiencies in others. Because of its superior control in the "Ferrostan" operation, the use of the meter has been extended to all subsidiaries of United States Steel producing electrolytic tinplate. Application for patent on the meter has been filed.

The BLOOM
TIME CYCLE REVERSAL SYSTEM

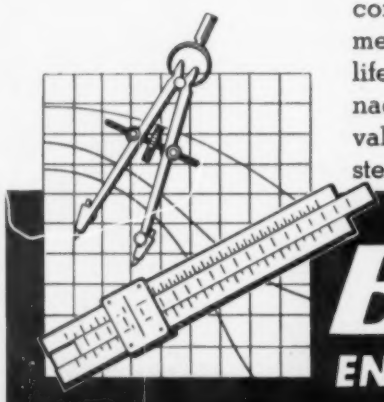
In this one compact cabinet..

ELECTRIC BRAINS
that don't forget—
FINGERS
that never tire



control all operations for the
FAST, AUTOMATIC REVERSAL
of open hearth furnaces!

Factory-wired, readily installed wherever convenient. Faster, smoother reversals mean greater production, longer checker life, greater fuel economy. Reverses furnace automatically on pre-set time intervals until changed. Compact, dust-proof steel cabinet.



BLOOM
ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 12, Pa.

THOMAS STEEL BUILDS COLD REDUCTION MILL

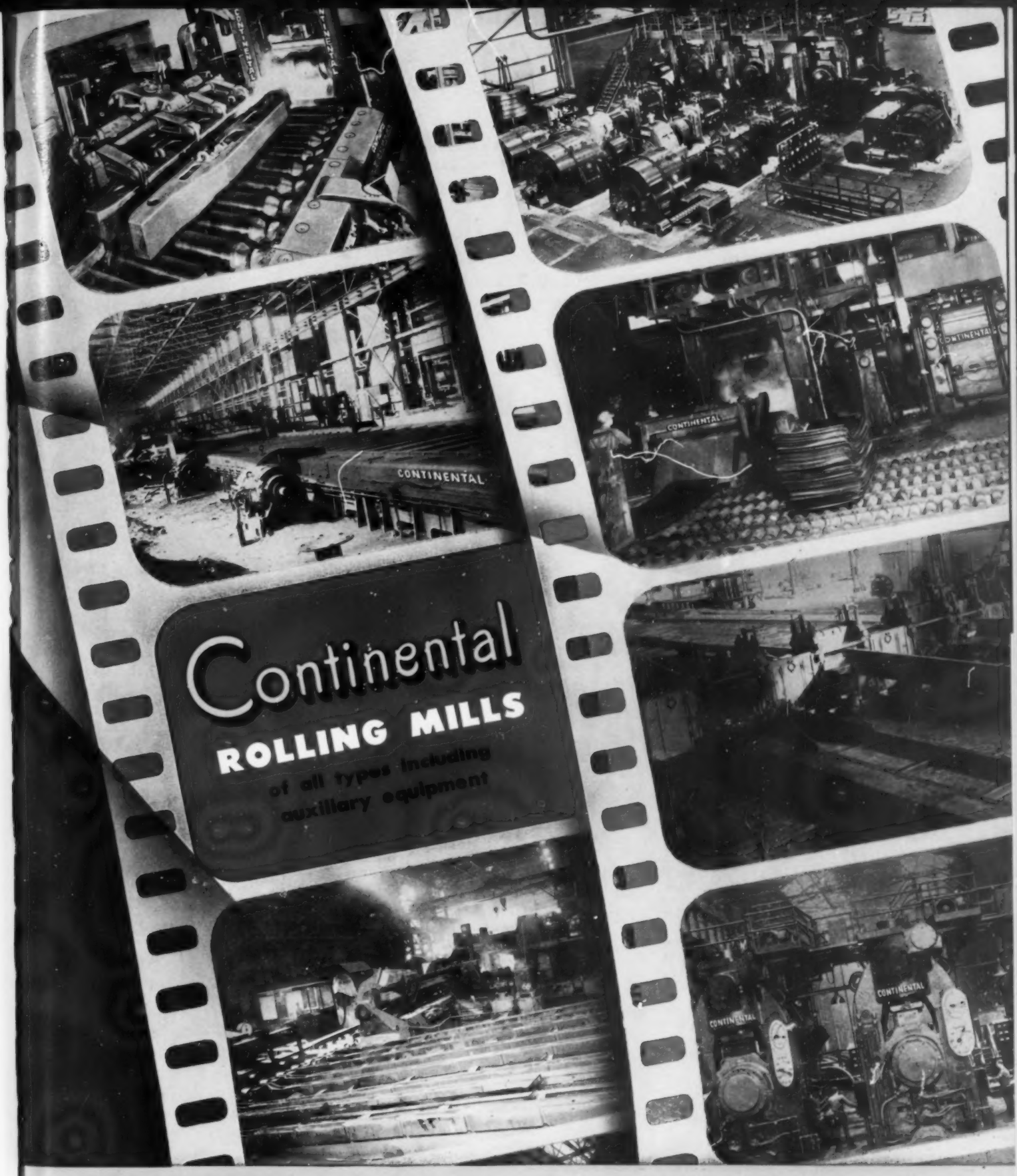
▲ Thomas Steel Co. has announced that a construction contract has been awarded to F. H. McGraw & Co. for a mill modernization program which is underway at Thomas' Warren, Ohio, plant. The construction will consist mostly of erecting a three-stand tandem cold reduction mill and making necessary building changes. The project will be completed in nearly five months. Mechanical equipment for the new mill will be supplied by United Engineering and Foundry Co., with Westinghouse supplying the main mill drives and General Electric Co. the auxiliary electrical equipment.

AIRCO SIMPLIFIES CORPORATE STRUCTURE

▲ Simplification of the corporate structure of Air Reduction Co., Inc., in a move to consolidate activities and increase efficiency of operations, was recently approved by the board of directors.

This change of corporate structure, which became effective on January 1, 1950, involves the liquidation of all the wholly owned domestic subsidiaries of Air Reduction. The respective businesses formerly conducted by the active domestic subsidiaries will be conducted by corresponding divisions of the corporation. Foreign subsidiary companies are not involved.

The divisions replacing the domestic subsidiaries will operate in the same manner and with the same or-

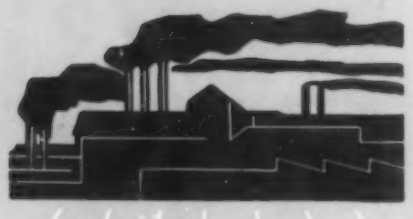


Continental

FOUNDRY & MACHINE CO.

CHICAGO · PITTSBURGH

Plants at East Chicago, Ind., Wheeling, W. Va., Pittsburgh, Pa.



Industry's Headquarters for
Carbon and Alloy Steel Castings
Rolling Mills and Equipment
Iron and Steel Rolls

ganizations as the companies they supersede. No changes in personnel are involved and each division head will report directly to the president of Air Reduction.

ITALIAN PLANT PURCHASES ALUMINUM ROLLING MILL

▲ Loewy rolling mill, division of Hydropress, Inc., New York, has received an order for a complete high-speed rolling mill for aluminum foil from one of the leading manufacturers in Italy. The installation consists of one 4-high breakdown mill and one 2-high finishing mill operating at 3000 fpm. It will have a production capacity of the thinnest aluminum foil of 400,000 lb per month. Two similar rolling mill plants which are being built by Hydropress for leading French companies will make France independent of aluminum foil imports.

AZED, INC. APPOINTS PITTSBURGH AGENT

▲ Azed, Inc., Waukegan, Ill., has recently appointed J. H. Overpeck Co., 1112 House Bldg., Pittsburgh, Pa., to distribute its line of detergents and accelerators for pickling baths, addition agents for galvanizing and zinc electroplating baths and secondary treatments for zinc surfaces. The territory covered by the Overpeck organization will include western Pennsylvania, eastern Ohio and part of northern West Virginia. The recently formed Azed, Inc., is a joint venture of Acme Steel Co. and Poor & Co.

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CAN SHOW
YOU
HOW...
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CONTROLLERS FOR
HEAT TREATING FURNACES
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FOR EVERY
NEED
TO IMPROVE
MANY PHASES OF
STEEL PROCESSING...
AND TO CUT YOUR
FUEL AND LABOR COSTS.
The bulletin illustrated is not just a piece of sales literature but a complete 24 page treatise on the instrumentation and automatic control of steel making and heat treating furnaces. You'll want a copy for your reference files, want to profit from its practical, authoritative information.
And remember as you read it, Hays engineers are thoroughly qualified and ready to work hand-in-hand with you in solving your own specific instrumentation and control problems . . . without obligation.
Write for your copy today . . . Ask for Bulletin No. 48-750 (covering heat-treating furnaces). Companion edition covering open-hearth furnaces will also be included.
THE HAYS CORPORATION, MICHIGAN CITY 13, INDIANA
Steel that's better, with more uniform grain structure . . . maximum production because of continuous equipment performance . . . fewer rejects . . . lower fuel, maintenance and labor costs—these are advantages you can count on when you use Hays instruments and controls for:
Annealing
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For indicating and controlling:
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Inquiries invited on any of these specific applications.
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Since 1901
COMBUSTION & INDUSTRIAL INSTRUMENTS & CONTROL
MICHIGAN CITY, INDIANA, U.S.A

BETHLEHEM RELEASES NEW MOTION PICTURE

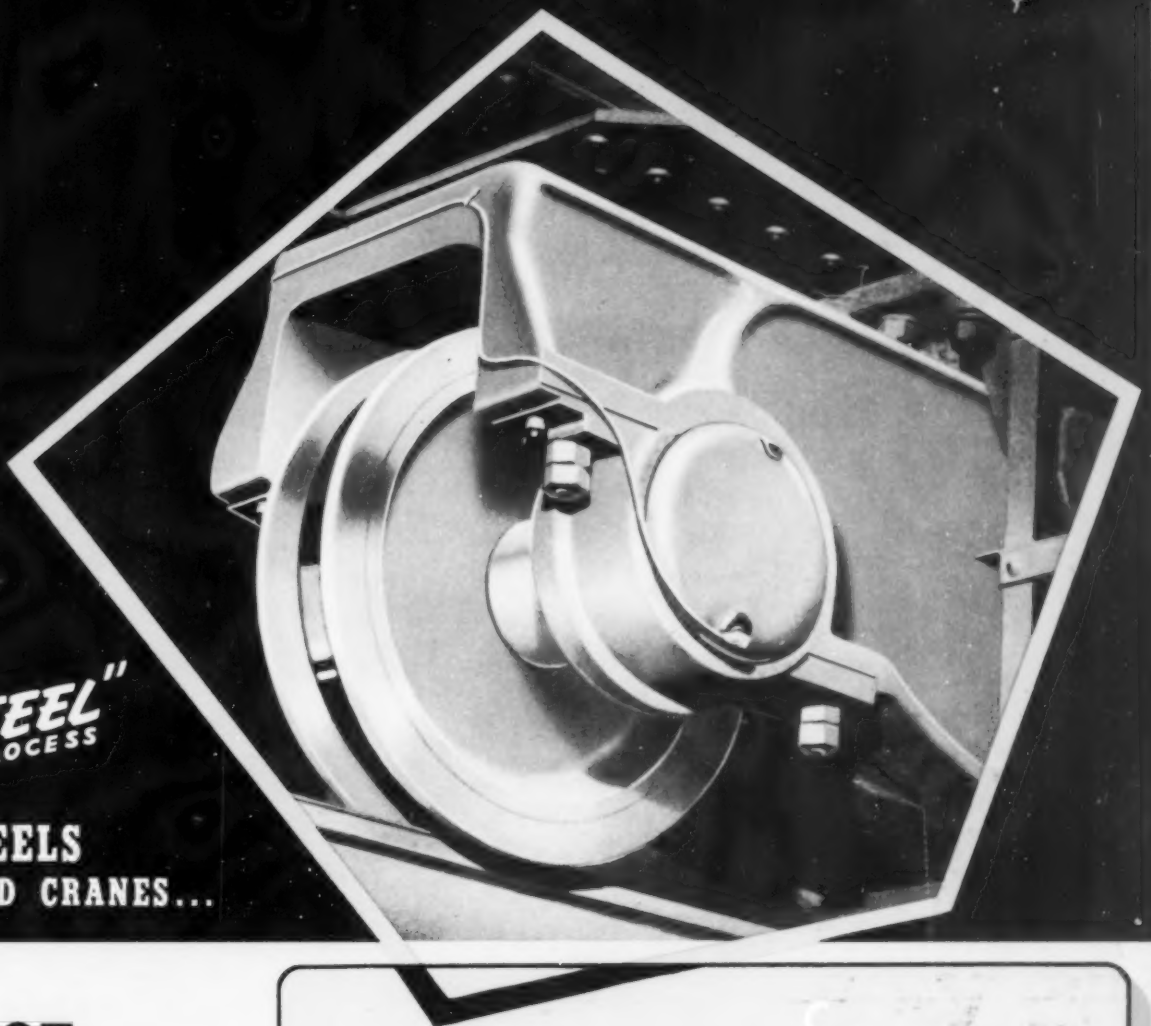
▲ Bethlehem Steel Co. announces the release of a new sound motion picture in black and white entitled "Alloy Steels — A Picture of Controlled Production." As the name implies, the picture depicts present-day manufacture of alloy and special steels, emphasizing particularly the care exercised in the control of all manufacturing processes.

Following a brief introduction to show a few important applications of alloy steels, the picture takes the audience to the laboratory, thence to the electric furnace department, the open hearths, blooming mills, hand mills and the new continuous bar mills. The continuous bar mills, which have just been installed, are among the most modern in existence.

Both chemical and spectrographic laboratory procedures for the analyses of steel are covered in detail, as are tests made on the finished-rolled, heat-treated and as-rolled bars. Controlled cooling and heat treatment are given special attention, as are finishing operations and long-range studies of the behavior of various types of alloy steel under all conceivable conditions.

Showing time is 43 minutes and the film is available in both 16 and 35 mm. "Alloy Steels" takes the place of Bethlehem's current motion picture on the same subject, "The Making of Alloy Steels." The latter was filmed several years ago and is now being taken out of circulation.

"Alloy Steels" may be obtained for showing by writing to the Publications Department, Bethlehem Steel Co., Bethlehem, Pa., or, on the West Coast, to Bethlehem Pacific Coast Steel Corp., 20th and Illinois Streets,



"TOOL STEEL" PROCESS

TRACK WHEELS FOR OVERHEAD CRANES...

provide

YEARS OF SERVICE AS COMPARED TO MONTHS FOR OTHER MATERIALS!

"Tool Steel" track wheels are providing up to **30 times** the life of ordinary wheels used in the same service!

This amazing superiority is substantiated by our customers' own records.

Investigate these **facts** today. You'll find the same unequalled quality built into other "Tool Steel" parts for cranes, including gears, pinions, brake and sheave wheels, axles and sheave pins!

WE GUARANTEE our products to give sufficient life over any other grade of hardened material operating in the same service to cover any difference in first cost. If our material fails to fulfill this guarantee, we will make good the deficiency in either cash or new material.

THIS GUARANTEE WAS ORIGINATED BY AND IS EXCLUSIVE WITH THE TOOL STEEL GEAR AND PINION CO.

HERE'S AN ACTUAL COMPARISON:

(From the customer's own records:)

WHEELS	AVERAGE LIFE IN MONTHS
High carbon cast	8 to 12
Manganese steel	12 to 18
Hardened rolled steel	16 to 20
"TOOL STEEL"	**over 168***

*After **14 YEARS** of service further records were deemed unnecessary.

This service life can be equalled by no other products!

Write today for complete information.

"TOOL STEEL" PROCESS

The Standard of Quality

for GEARS • PINIONS • ROLLS • WHEELS *and other* HARDENED PRODUCTS

THE TOOL STEEL GEAR & PINION CO.

CINCINNATI 16, OHIO, U. S. A.

San Francisco, Calif. There is no charge for the use of the film other than the cost of prepaid return shipment. At least three weeks' notice should precede specific showing dates.

PAINT USE FOR SAFETY REDUCES ACCIDENTS

▲ Safety supervisors of steel companies are using paint more widely to help reduce accident rates, according to American Iron and Steel Institute.

In some plants, the handrails and edges of stairs are vividly painted. Safe aisles are marked on floors where feasible. Electrical fixtures are brightly daubed to make them readily discernible.

So successful has the "color-for-safety" idea proven, that in some steel plants efforts have been made to standardize the meanings of certain colors. Red commonly indicates fire protection equipment. Orange may mark moving parts of machinery and yellow an obstruction hazard, such as stairs.

KAISER PIPE MILL TO START OPERATION

▲ The new electric weld pipe mill at Kaiser Steel Corp., Fontana, Calif., which will be capable of producing pipe in sizes from 5 in. to 14 in., and our new 86 in. hot strip mill, will be starting operation shortly after the first of the year. These facilities will add to the flexibility of the Fontana plant and will also provide the west coast with additional steel products.

S. P. KINNEY MOVES TO CARNEGIE, PA.

▲ S. P. Kinney Engineers, Inc., are moving their offices from Pittsburgh, Pa., to Carnegie, Pa., where they have equipped a plant to manufacture the blast furnace equipment which they sell. The shop is arranged to do machine and plate work and is equipped with vertical boring mills ranging to 10 ft -0 in., horizontal boring mills, milling machines, and all machines necessary to build blast furnace equipment. These shops are also equipped to do various types of welding and pipe bending and fitting.

It is planned to manufacture blast furnace stove bottoms, stove burners, primary and combined primary and secondary gas washers for blast furnace and other gases, all types of blast furnace valves, self-cleaning and basket water strainers, and other miscellaneous equipment.

INDUSTRIAL VENTILATING FIRM CHANGES NAME

▲ The Powermatic Ventilator Co. of Cleveland, Ohio, makers of "Iron Lung" roof ventilators, intake units, and related items has announced a change of name, effective immediately.

The new name, Iron Lung Ventilator Co., incorporates the company's widely known trade name for its several types of industrial ventilating equipment. Headquarters remain at 4019 Prospect Avenue, Cleveland 3, Ohio.

WELDCO Pickling Crates

With the New Pierced-Type Cross Members Offer Bigger Payloads— Longer Service Life

• These six Weldco pickling crates, made of Monel, are now in use in a Gary, Indiana, sheet mill. Sturdy and long-lasting, they're pickling sheet steel in a 5 to 10% sulphuric acid bath at 160° to 180° F. An extra feature of these Monel crates is the new, pierced-type cross member, with these cost-cutting advantages:

1. Greater strength—more tonnage per load.
2. Less hole distortion or enlargement. The taper pins remain tight—do not become loose or wobble.
3. Less time needed for loading, as less time required for placing pins, due to tapered hole.
4. Only a small surface is exposed to attack by acid. Cross member retains its strength longer, and there are fewer replacements.

Why not find out how these long-lasting Weldco crates can improve your pickling operations? Write or phone today for complete details and descriptive literature.

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

3720 OAKWOOD AVENUE . . . YOUNGSTOWN 9, OHIO

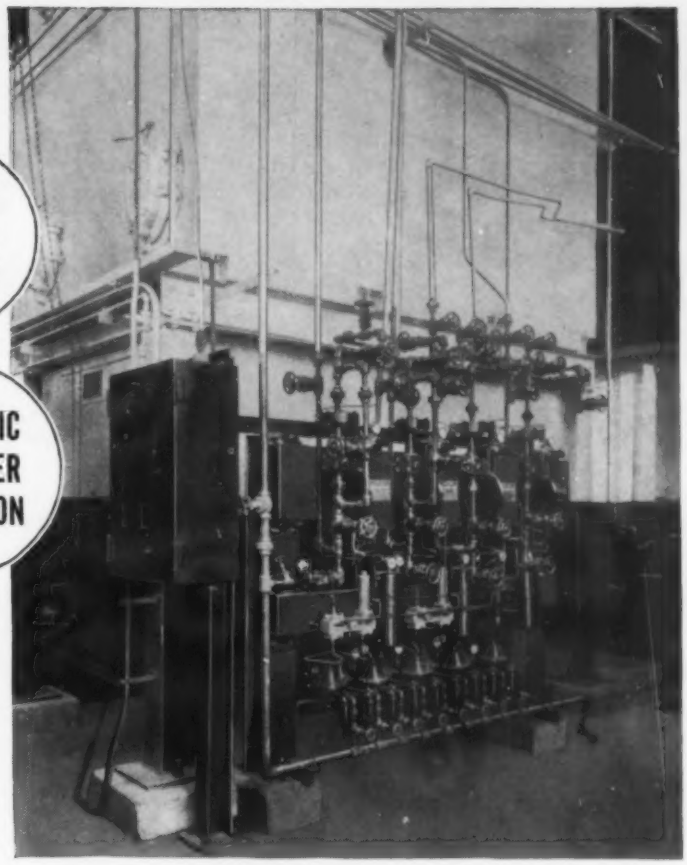
AUTOMATIC COMBUSTION CONTROL

RING BALANCE METERS

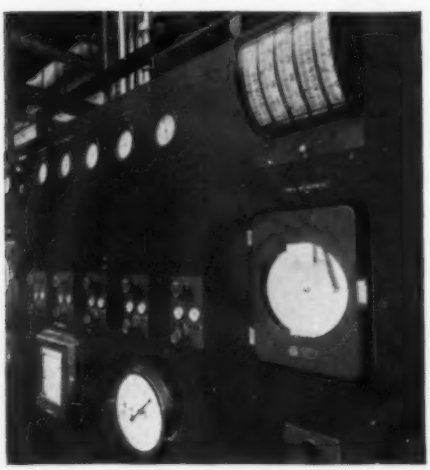
BY HAGAN

AUTOMATIC FEEDWATER REGULATION

AT THE CLEVES, OHIO, REFINERY OF THE GULF REFINING COMPANY

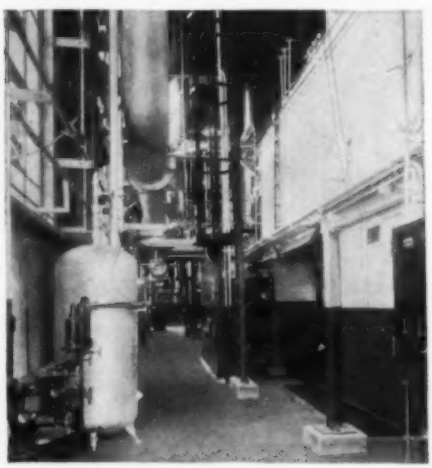


Components of the Hagan automatic feedwater regulation and combustion control systems are mounted at the side of each boiler, giving easy access for adjustment or servicing.



Separate instrument panels are provided for each boiler. Two Hagan Ring Balance Meters are mounted on each panel.

Below—*General view showing front of boilers and instrument panels in Gulf Refining Company refinery at Cleves, Ohio.*



Recent expansion of the refinery of Gulf Refining Company at Cleves, near Cincinnati, included the installation of two new boilers, each with a capacity of 70,000 pounds of steam per hour, and operating at 685 psi. Fuels used are refinery waste gas and oil, either singly, or in combination.

These new boilers are equipped with Hagan Automatic Combustion Control, Hagan Automatic Feedwater Regulation, and Hagan Ring Balance Meters.

The combustion control is a Hagan Differential Master system. With this system, waste gas is burned when available and is automatically supplemented or replaced by oil as necessary. Fuel feed is changed instantly to compensate for fluctuations in calorific value of fuel or changes in steam demand and excess air is automatically maintained in accordance with actual Btu. input.

Hagan Automatic Feedwater regulation is a multiple circuit system which proportions feedwater to steam flow and modifies feedwater flow in accordance with water level in the boiler. Thus the system not only holds water level accurately in a steady steaming state, but also "irons out" in an optimum pattern, the mutual disturbances existing between the steam generating circuits and the water flow circuits of the boiler in changing from one steam rate to another.

Two Hagan Ring Balance Meters are used with each boiler. One records steam flow, air flow and steam pressure; the other records feedwater flow and steam drum water level.

We will be glad to supply full information on Hagan Combustion Control, Hagan Automatic Feedwater Regulation and Hagan Ring Balance Meters. Write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

HAGAN CORPORATION

BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
THRUSTORQ FORCE MEASURING DEVICES

ELIMINATE STOOL STICKERS

with "NATIONAL" Graphite Stool Inserts!

*** Here are the conclusions drawn from five years of testing "National" graphite stool inserts:**

1. Cast-in graphite stool inserts eliminate stool stickers.

2. Cast-in graphite inserts, of proper grade and size, produce a stool which will outlast an ordinary all-iron stool by as much as 86%.

3. Cast-in graphite inserts do not adversely affect the quality of the steel ingot.

ADVANTAGES ARE:

Track time for ingot trains held to a minimum. Maintenance cost of stripper cranes materially reduced. Time and labor saved all along the line.

*Write for free reprint of "Graphite Stool Inserts for Big-end-down Molds" from the September, 1949, issue of *Iron and Steel Engineer*. Address Dept. IS

Use Carbon Mold Plugs for Plug-bottom Molds!

No contamination of ingot. • May be used more than once; no stickers. • Light, strong, easy to handle. • Consistently accurate in dimension. • Resist thermal shock and hot-metal erosion.

The term "National" is a registered trade-mark of

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Unit of Union Carbide UCC *and Carbon Corporation*

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Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

Foreign Department: New York, U.S.A.

These products sold in Canada by Canadian National Carbon Company, Ltd., Toronto 4.

Personnel News...

Charles R. Cox has resigned as president of Carnegie-Illinois Steel Corp., Pittsburgh, Pa., to become president of Kennecott Copper Corp., New York, N. Y. In assuming the presidency of Kennecott Copper, Mr. Cox became head of the largest copper-producing company in the world. He succeeds in this office the late E. T. Stannard, who recently died in an airplane accident in Canada.

Clifford F. Hood, president of American Steel and Wire Co., Cleveland, Ohio, has been elected president of Carnegie-Illinois Steel Corp., Pittsburgh, Pa. Mr. Hood succeeds **Charles R. Cox,** who has resigned as president of Carnegie-Illinois Steel Corp. to become president of Kennecott Copper Corp. Mr. Hood's rise from an operating clerk in one of the plants of American Steel and Wire Co. to the presidency of the largest steel-producing subsidiary of United States Steel is an American success story. He was born near Monmouth, Ill., on February 8, 1894. Mr. Hood attended public schools in Galesburg, Ill., and later majored in electrical engineering at the University of Illinois. Following his graduation from college in 1915, Mr. Hood became asociated with Packard Electric Co. of Warren, Ohio. In 1917, he became an operating clerk in the Worcester, Mass., plant of American Steel and Wire Co. His work there was interrupted by the First World War, in which he served overseas in the coast artillery. Resuming his career with American Steel and Wire Co. in 1919, Mr. Hood was foreman of the electric cable department in South Works, at Worcester, Mass., until 1925 when he was appointed assistant superintendent of the plant. In 1928, he was made superintendent of South works, Worcester, and four years later was advanced to post of assistant manager of the entire Worcester district operations. On January 1, 1933, he became manager of operations in the Worcester district and in 1935, he was transferred to Cleveland as vice president in charge of operations. Two years later, he was elected executive vice president, and on January 1, 1938, president of the company.

Harvey B. Jordan, vice president in charge of operations of American Steel and Wire Co., Cleveland, Ohio, since 1939, has been elected president. Mr. Jordan succeeds Clifford F. Hood, who has been elected president of Carnegie-Illinois Steel Corp. Mr. Jordan was born in Lansing, Mich., on July 21, 1895. He attended the public schools of New Castle, Pa., and San Diego, Calif., before matriculating at Pennsylvania State College, where he majored in industrial engineering. Mr. Jordan has seen service with American Steel and Wire Co. for 35 years, having taken summer vacation employment with the company in 1914 as a chemist at Central Furnaces and Docks, in Cleveland, joining the company permanently as foreman of that plant the following year. He worked his way up through the ranks to the positions of first general foreman and then assistant superintendent, being made superintendent of the plant in April, 1929. In May, 1933, Mr. Jordan was transferred to the office of the vice president, where he did field work, and in the following year was promoted to head the metallurgical department. He held this position until December, 1935, when he was made manager of the Cleveland district. In January, 1937, he was named assistant vice president, and in March, 1939, was appointed vice president in charge of operations.

L. J. Westhaver was named manager of operations of Geneva Steel Co., Geneva, Utah. Mr. Westhaver goes to Geneva Steel from Duluth, Minn., where he has been manager of operations for the American Steel & Wire Co., another U. S. Steel subsidiary.

H. G. Batcheller, president, was elected chairman of the board of Allegheny Ludlum Steel Corp., Pittsburgh, Pa., with **E. B. Cleborne,** executive vice president, succeeding him as president. Mr. Cleborne in turn was succeeded by **Edward J. Hanley,** vice president in charge of finances and treasurer. **Clark W. King,** vice president, was elected treasurer, succeeding Mr. Hanley in that position. **T. Ames Wheeler,** manager of the cost and statistics department, was elected to the newly created office of controller.

James E. Lose, vice president in charge of operations, Carnegie-Illinois Steel Corp., Pittsburgh, Pa., has been elected executive vice president. Mr. Lose, who began his business career with Carnegie Steel Co., one of the predecessors of Carnegie-Illinois, in 1910, becomes the first official to occupy this newly-created position with

CLIFFORD F. HOOD

HARVEY B. JORDAN

L. J. WESTHAVER

E. B. CLEBORNE

LOOK TO THE FUSE LEADER FOR PRODUCTION PROGRESS

Double Fibre Bridge Assembly
Increases Strength 10 Times

WARE HI-LAG Fuses have the strongest, most rigid knife blade assembly ever designed in fuses. The two heavy fibre bridges are supported by sturdy brass brackets which add greatly to the strength of the assembly. These bridge supporting brackets are attached to the copper knife blades and contact the entire end of links so that current flows through the brackets as well as the blades over a large area. Another reason for WARE HI-LAG Fuse's cool operation.

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4460 W. LAKE ST. CHICAGO 24, ILL.

Browning Mill Type Cranes are built in accordance with A. I. S. E. specifications. They incorporate the types of motors and controls on which your mill or industry has standardized. This flexibility adapts your VRB crane *perfectly* to your needs. Only the finest materials are employed. Browning heavy duty cranes meet the most rigid demands and satisfy the most critical users. Our design, placing plenty of strength wherever needed, is the outgrowth of 48 years' experience in the crane industry.

"Built as you yourself would build them"

Write for our Bulletin "S".

VICTOR R. BROWNING & COMPANY, Inc.
BOX 309, WILLOUGHBY (CLEVELAND), OHIO
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

company. Mr. Lose has had a distinguished career in the operating department of Carnegie-Illinois, entering the executive branch of the operating activities of the company by way of the mills themselves. He started at Carrie furnaces, Rankin, Pa., after specializing in mechanical engineering at Carnegie Institute of Technology in Pittsburgh. From Carrie furnaces he went to the blast furnace department of Homestead steel works as a tracer in the drawing room, and in turn was a draftsman, stock house foreman, superintendent of construction, assistant superintendent and superintendent of blast furnaces. In April, 1928, Mr. Lose was appointed assistant general superintendent of Homestead works, one of Carnegie-Illinois' largest basic steel-producing plants, and on October 1, 1930, was appointed general superintendent. He was elected vice president in charge of operations of Carnegie Steel Co., October 1, 1933, assuming the same position when Carnegie-Illinois Steel Corp. was formed in 1935.

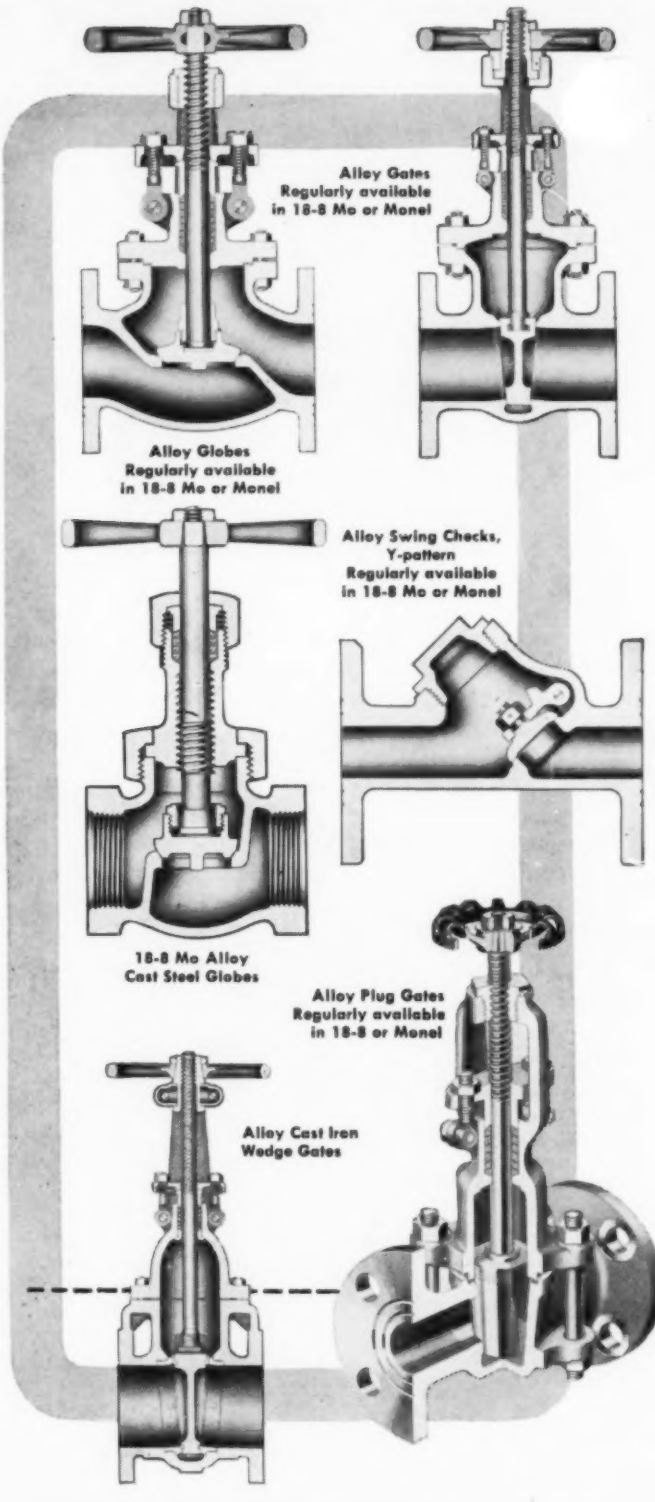
R. J. Leckrone was appointed chief engineer of Mackintosh-Hemphill Co., Pittsburgh and Midland, Pa. Mr. Leckrone will direct the company's engineering of rolling mill equipment. He will also assist in the company's machinery sales program. Mr. Leckrone has been active in the design and sale of rolling mill equipment during the past 20 years. He has been affiliated with Morgan Engineering Co., Alliance, Ohio; E. W. Bliss Co., Salem,

R. J. LECKRONE

Ohio; Continental Foundry and Machine Co., Pittsburgh and the Lewis Foundry and Machine division of Blaw-Knox Co., where he served for eight years as chief designing engineer. Mr. Leckrone spent three years in Russia as chief engineer in charge of American specialists in the design and installation of rolling mill equipment for the U.S.S.R. at Kramatorskie, in the Ukraine. He is a mechanical engineering graduate of the University of Pennsylvania.

G. G. Beard was elected to executive vice president of the United Engineering and Foundry Co., Pittsburgh, Pa. Mr. Beard began his service with United as an engineer in 1927. He became manager of the proposal department in 1935, and was placed in charge of sales engineering in 1943. He was elected a vice president in 1943 and became a director of the company in 1944. Mr. Beard is also president of Lobd-United

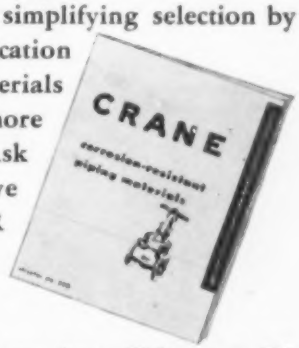
Do you know all you should about CRANE Corrosion-Resistant Valves?



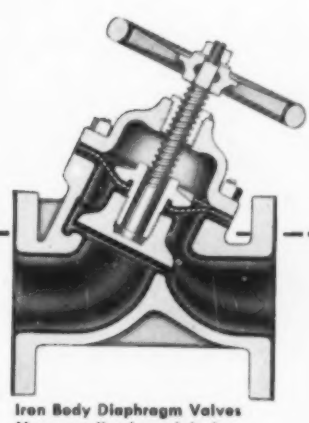
Do you know that this Crane line offers an unusually complete assortment of corrosion-resistant gates, globes, angles and checks? That these valves are regularly available in those alloys found to be most successful under the widest range of corrosive conditions? That they are ideal for process industries where maximum product purity, avoidance of product discoloration, and resistance to corrosion are of prime importance?

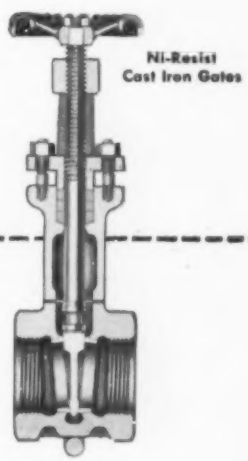
SEND FOR THIS NEW CIRCULAR

For your convenience, Crane has prepared a 36-page circular that gives you a comprehensive showing of the Crane corrosion-resistant line—including a number of outstanding new developments. This informative guide, in addition to simplifying selection by furnishing essential specification data, recommends those materials best suited for handling more than 250 different fluids. Ask your Crane Representative for a copy, or WRITE FOR CIRCULAR NO. 320. No obligation.



CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas





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FOR EVERY PIPING SYSTEM

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Using Morganite Brushes is one sure way to better motor and generator performance. The Morganite link control method of manufacture guarantees proper design, highest quality materials and accurate workmanship. Morganite engineering service assures competent, practical collaboration on every brush problem.
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LONG ISLAND CITY 1, NEW YORK
Manufacturers of Morganite Self-Lubricating Carbon Specialties including Seals, Rings, Valves, Slides, Bearings, etc., and Carbon Piles

Co. of Wilmington, Del., and of Stedman's Foundry and Machine Works, Inc., Aurora, Ind. These companies are wholly owned subsidiaries of United Engineering.

Edwin R. Jung was appointed general sales manager of Clark Controller Co., Cleveland, Ohio. Mr. Jung is a native Clevelander, and a graduate of Purdue University with a bachelor of science degree in electrical en-

EDWIN R. JUNG

gineering. He has been with the company for twenty-two years, serving in sales capacities in various areas, and was for many years Atlantic Coast regional manager, with offices in New York. He went to the Cleveland home office as manager of industrial sales, September 1, 1947, later becoming assistant sales manager.

Don L. Orton has been elected vice president and a director of Post Electric Co., Inc., electrical engineers and constructors of Chicago, Ill. Mr. Orton has recently

DON L. ORTON

resigned as a vice president of Clark Controller Co. with whom he was connected for 20 years, 11 of which were spent in the Chicago and Gary area.

J. E. Jacobs has been appointed an assistant general manager of the Lackawanna, N. Y., plant of Bethlehem Steel Co. Mr. Jacobs is a graduate from Carnegie Institute of Technology. After some years service on the metallurgical advisory board and with various other steel companies he came to Bethlehem in 1935, as re-

yes... an oil seal that's tailor-made to *resist* corrosion

● If corrosive conditions are shortening the life of your oil seals, the Johns-Manville Clipper Seal should provide a practical solution to your problem.

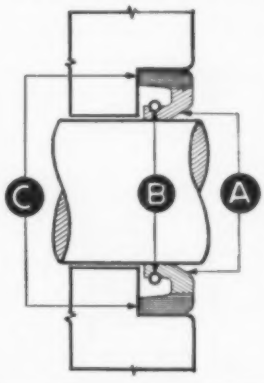
Here's why: The Clipper Seal's molded body is entirely non-metallic and is, therefore, unaffected by most forms of corrosion. To meet special conditions, the garter spring which holds the lip in contact with the shaft can be furnished in various corrosion-resistant metals . . . *or Clipper Seals of special design that do not require garter springs may be used.*

The one-piece, concentric molded design of Clipper Seals also assures a number of other advantages. The hard, tough outer heel of the Clipper Seal is resilient enough to conform even to a slightly out-of-round cavity. And the soft, pliable inner lip always maintains a light, but positive sealing pressure on the shaft, with minimum wear on the seal.

Clipper Seals are quick and easy to install, may be had in split or endless types, are available in sizes from ¼" I.D. up to 66" O.D. If you have a special sealing requirement, or wish to consult about a special design problem, write Johns-Manville, Box 290, New York 16, N. Y.

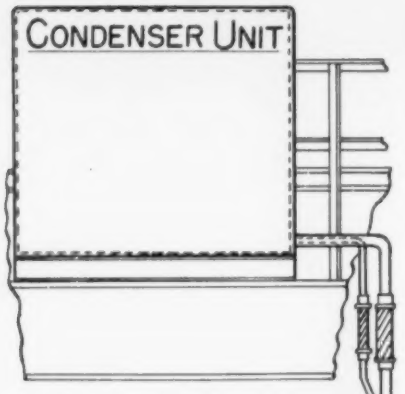
JM PRODUCTS

Here's how *Clipper Seal* works:



The flexible lip (A) is held in light but firm contact with the shaft by means of the garter spring (B). Pressure on shaft is carefully pre-determined to minimize wear, yet effectively seal against leakage. The rigid heel (C) provides a press fit in the cavity, assuring a tight lubricant-retaining seal at this point also.

Johns-Manville **PACKINGS & GASKETS**



COOLING EFFICIENCY INCREASED 30%

LINTERN AIRE-RECTIFIER

In these new Aire-Rectifiers — of the "split" unit type — troublesome and expensive air ducts have been eliminated and cooling efficiency increased as much as 30% in the cab.

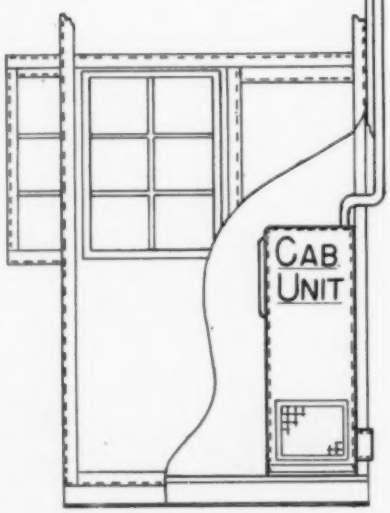
The condenser is located at any convenient place on crane and evaporator (cooling coil) is placed in cab. The two units are connected with refrigerant lines properly secured and protected against breakage. Condensers are air-cooled, assuring trouble-free service with but little maintenance.

These Aire-Rectifiers will hold properly insulated cabs at a cool 85° F and relative humidity of 30% to 50% at ambient temperatures of 170° without excessive head pressures or wear on the machine.

THE LINTERN CORPORATION

54 LINCOLN AVENUE • BEREA, OHIO

Send for new bulletin AC 4912, just out, containing complete information.



search engineer. The following year he was transferred to Lackawanna where he served successively as assistant engineer of tests, assistant to the general manager, and management's representative in charge of industrial relations. In this position he is being succeeded by **B. A. McDonald** who has more than twenty years of service in the industrial relations department, as safety engineer, as assistant in charge of compensation and relief, and, since 1943, as assistant management's representative.

W. B. Shirk has been made director of industrial products engineering in the newly-formed product development and product engineering section of Gulf Oil Corp., Pittsburgh, Pa. Mr. Shirk is an electrical engineering graduate of Lehigh University, 1920. He received his early education in Lebanon, Pa., grade and high schools. After some years with Bethlehem Steel Corp. and the Westinghouse Electric Corp., he joined Gulf as a lubrication engineer in 1932. He has recently been serving as chief industrial lubrication engineer in lubricating sales. His new appointment places Mr. Shirk in supervision of the application of fuels and lubricants to prime movers and industrial plants.

W. B. SHIRK

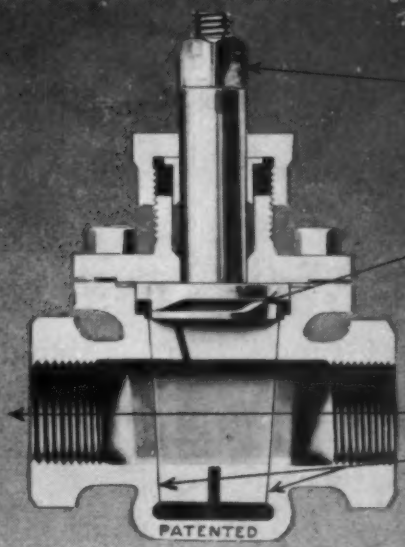
Neele E. Stearns was elected to the new office of executive vice president of the Inland Steel Products Co., a subsidiary of the Inland Steel Co. Mr. Stearns, who has been associated with Inland since 1940, has served for the last several months as an acting vice president of the Inland Products Co., on leave of absence from his post as assistant general sales manager of the parent organization in Chicago. He relinquishes the latter post to take over his new duties in Milwaukee, Wis.

James McConnell has been appointed superintendent of merchant mills at Youngstown Sheet and Tube Co.'s Indiana Harbor, Ind., works. He succeeds **Fred A. Schuessler** who died last summer. Mr. McConnell is a native of Munhall, Pa. He attended public schools in Butler, Pa., then went to Lehigh University. His first part-time job in industry was kick-off operator in the 12-in. mill of Forge Steel Wheel Co. in Butler at the age of 16. This was followed by line jobs of billet yard stocker, open hearth clerk, stock boss at the bessemer and open hearth and third helper in an open hearth department. He also served as a merchant mill foreman with Republic Steel Corp. in Chicago. Mr. McConnell joined Youngstown Sheet and Tube Co. as finishing

Preferred for over 50 Years for...

LOW FIRST-COST
LOW MAINTENANCE
LONG SERVICE

and Quick, Positive Operation



1. Quarter-Turn fully opens or closes.

2. Cam serves as positive stop, and automatically seals valve against leakage by pressing seating surfaces firmly together.

3. Straight-line fluid flow. Minimum pressure drop.

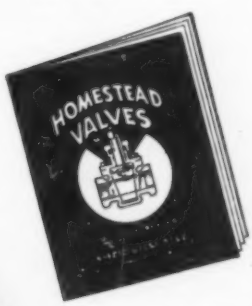
4. Seating surfaces protected in both open and closed positions.

5. Homestead Cam-Seald Quarter-Turn Valves are made in straight-way, 3-way and 4-way types, and in metals for most valve needs; for pressures to 3,000 pounds, and temperatures to 750° F.

HOMESTEAD Cam-Seald QUARTER-TURN VALVES

Besides being the most economical, maintenance-free, long service valves for handling air, water, gas, oil and other fluids, Homestead Quarter-turn valves are unsurpassed for quick, positive operation. A simple quarter-turn fully opens or closes them; and the patented Homestead cam holds seating surfaces in contact at all times. Seating surfaces are protected in both the open and closed positions so that corrosive fluids or grit cannot cause damage and valve failures. Straight, unobstructed fluid passage assures "full flow" and minimum line pressure drop.

To these important features add the rugged construction typical of all Homestead valves and you have the reason why hundreds of plants in all types of industry have insisted on Homestead Cam-Seald Quarter-Turn Valves for half a century.



For complete information write for Valve Reference Book No. 38.

HOMESTEAD VALVE MFG. COMPANY

"Serving Since 1892"

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CORAOPOLIS, PA.

Hyde Park

CHILLED and ALLOY IRON ROLLS

Rolling Mill Machinery

GRAY IRON CASTINGS

HYDE PARK FOUNDRY & MACHINE CO.

HYDE PARK, PA. (PITTSBURGH DISTRICT)

here's what they say about CrysCoat

FOR PREPARING METAL SURFACES FOR PAINTING, THERE IS NOTHING TO EQUAL THE OAKITE CrysCoat* PROCESS!

YES, painting and finishing superintendents, product engineers, chemists and metallurgists are learning that—*with minimum equipment, in minimum time, at minimum cost*—the OAKITE CrysCoat PROCESS:

- cleans metal surfaces and conditions them for painting
- improves the adhesion of paint to metal
- prevents corrosion before metal is painted
- localizes corrosion under paint if finish is scratched or damaged

FREE Write to Oakite Products, Inc., 19 Thames St., New York 6, N. Y., for illustrated folder F7642 which tells how CrysCoating *cuts cost 10 ways.*

*Reg. U. S. Pat. Off.

OAKITE 1909 1949 40th ANNIVERSARY YEAR

OAKITE

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INDUSTRIAL CLEANING MATERIALS • METHODS • SERVICE

Technical Service Representatives Located in Principal Cities of United States and Canada

end foreman in the Indiana Harbor works merchant mill in May, 1931. He was promoted to general mill foreman in 1936 and in February, 1938, was made assistant superintendent of the merchant mills.

Roy M. Welch, assistant to the president of Youngstown Sheet and Tube Co., has retired after 48 years service.

Myron S. Curtis was appointed assistant to the president of Youngstown Sheet and Tube Co., Youngstown, Ohio. A native of Washington, D. C., Mr. Curtis attended public schools there, then went to George Washington University specializing in chemical engineering. In October, 1911, Mr. Curtis joined Youngstown Sheet and Tube Co., working in the tube mill at Campbell, Ohio. The following year he was sent to Harvey, Ill., as a foreman in Western Conduit Co., a subsidiary. Within a few months he was assistant superintendent of the plant. Late in 1912 the plant was dismantled and

MYRON S. CURTIS

moved to Youngstown. Mr. Curtis returned here as assistant superintendent of the conduit department at the Struthers plant. The following year he was appointed general foreman of the tube galvanizing department. In 1915 Mr. Curtis was named the company's first chief inspector. Four years later he was named special agent, product claims, and held that post for seven years, then was appointed Youngstown district sales manager. In 1929 Mr. Curtis was appointed advertising manager and the following year was made manager of sales promotion, a position he has held ever since. Last year he also was appointed manager of the company's industrial development division.

John A. Slenker has been named manager of operations of the Duluth district of the American Steel & Wire Co. Succeeding Mr. Slenker as general superintendent of the Duluth works will be **Clarion A. Purbaugh,** formerly division superintendent, open hearth. **Keith H. Moody** has been appointed to succeed Mr. Purbaugh.

William A. Streaker, a recent graduate of the University of Illinois, has joined Atlas Mineral Products Co. as a chemical engineer.

C. J. Garrigan has been appointed manager of S. P. Kinney Engineers, Inc., Mr. Garrigan became associated with S. P. Kinney Engineers in 1947 as sales engineer and became manager of sales in 1948. Before association with S. P. Kinney Engineers, Mr. Garrigan

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4 NEW PENNSYLVANIA POLE STAR TRANSFORMERS

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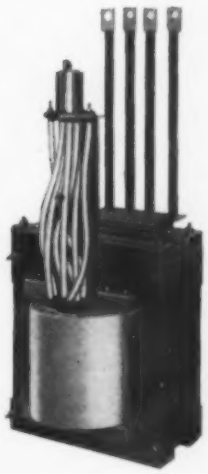

Interior assembly of 75 Kva POLE STAR. Core can be taken apart and rebuilt without changing the core loss or exciting current.

The new 100 KVA POLE STAR TRANSFORMER

is **35%** *lighter*

requires **36½%** *less oil*

covers **35½%** *less floor area*

than the 100 KVA Stacked Core Transformer it replaces

Now a COMPLETE LINE OF POLE STARS from 3 KVA through 100 KVA

The four transformers now added to the POLE STAR line are fundamentally the same as the original POLE STARS. Cores are wound of cold rolled steel. Core laminations are individually lapped for low exciting current and ease of disassembling and rebuilding the core and coil unit. On 2400 and 4800 volt units straight, side-issuing, high voltage bushings, with insulating caps, replace pockets and pocket bushings. Transformers are of Sealed Tank construction. Synthetic rubber gaskets are used throughout.

In other words: The POLE STAR is a better transformer than the stacked core transformer it replaces. It operates with greater efficiency and at less cost. It is lighter in weight, smaller in dimensions, cheaper to store and easier to install.

***Pennsylvania* TRANSFORMER COMPANY**

PITTSBURGH 12, PENNSYLVANIA

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Gray Iron Castings

was district sales representative for Clinton Machine Tool Co. and Turchan Follower Machine Co. Prior to this he was associated with Mesta Machine Co., in the capacity of assistant works engineer at their naval ordnance plant, coming to Mesta from Pittsburgh Rolls Division of Blaw-Knox Co. in 1942 where he has served as maintenance supervisor.

John P. Roche, vice president of Heppenstall Co., Pittsburgh, Pa., was elected president of the Machine Knife Association. The Machine Knife Association is composed of manufacturers of metal and wood cutting knives.

John E. Payne has been appointed manager of Westinghouse Electric Corp.'s central district. Mr. Payne will have complete supervision of the Westinghouse apparatus business in the Pittsburgh, Cleveland, Detroit, and Cincinnati areas and will make his headquarters in Pittsburgh.

Mr. Payne was graduated from the Alabama Polytechnic Institute in 1925 as an honor student with a de-

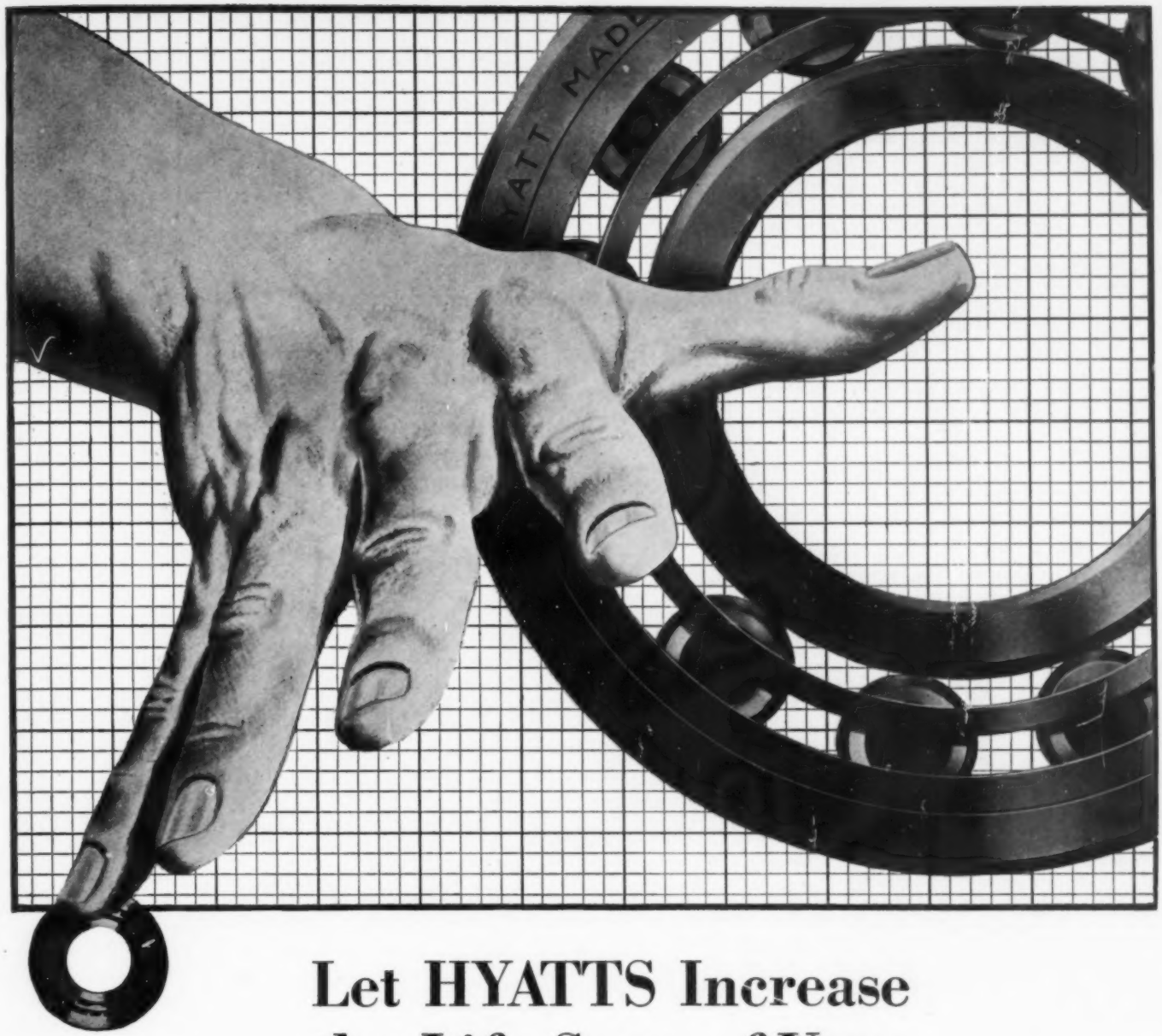
JOHN E. PAYNE

gree of bachelor of science in electrical engineering and joined Westinghouse immediately thereafter. After a year on the company's graduate student training course, he went into the general engineering department. He was an industrial salesman in the Pittsburgh office from June, 1927, until March, 1933, when he was appointed manager of the machinery resale section. In July, 1934, he was named manager of industrial sales for the central district, and became headquarters industrial sales manager in February, 1947. In October of that year he was appointed manager of all industry sales departments.

Ivor D. Sims, assistant purchasing agent of Bethlehem Steel Co., Bethlehem, Pa., has been appointed purchasing agent. Mr. Sims joined Bethlehem in 1933 as a junior buyer. He was advanced to buyer in 1939, and, in 1944, to assistant purchasing agent.

Thomas A. Brown has been appointed assistant manager of operations of the Pittsburgh and Graham plants of Pittsburgh Screw and Bolt Corp. Mr. Brown was formerly division superintendent of the McDonald Mills of Carnegie-Illinois Steel Corp. at Youngstown, Ohio.

J. E. Simonin has been appointed works manager of Pittsburgh Steel Co.'s Allenport, Pa., plant. Mr. Simonin has been at the Allenport plant 20 years and has been plant metallurgist 11 years. He is a graduate of Penn State.



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● Electrodes used in production of electrically welded pipe or tubing.
● Copper Welding Bells. U. S. Patent No. 1,973,680.

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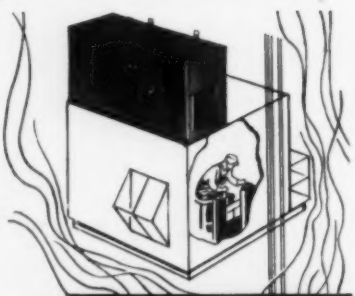

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W. F. Huntley was named assistant superintendent, blast furnace department, succeeding **E. H. Riddle** at the Aliquippa, Pa., works of Jones and Laughlin Steel Corp.

Frank M. Lewis was appointed district representative in the Pittsburgh area for General Electric's construction materials department. Mr. Lewis, formerly with the H. Lee Reynolds Co. of Pittsburgh, will take over field assignments for G-E wire and cable, wiring devices, and conduit products. He will make his headquarters at 2144 Oliver Bldg., Pittsburgh, Pa.

William O. Walk has been appointed division superintendent, heat treating and forge division at Homestead works of Carnegie-Illinois Steel Corp. He began with U. S. Steel as a metallurgist at Clairton, Pa., in 1930, and has been assistant to the general superintendent at Homestead since 1946. He succeeds Albert B. Steigerwalt, deceased.

Thomas D. Hess has joined Youngstown Sheet and Tube Co. as assistant superintendent of the open hearth department at its Indiana Harbor, Ind., works. Mr. Hess attended public schools in Mauch Chunk, Pa., and later graduated from Lehigh University with a bachelor of science degree in metallurgical engineering. Mr. Hess then joined Bethlehem Steel and after a training course was assigned to the open hearth department. He served as third helper, second helper, first helper, then was melter for five years. Before joining Youngstown, he was assistant superintendent of the open hearth department for Crucible Steel Co. at Midland, Pa.

John B. Sutton, Jr., has been elected president and general manager of Sutton Engineering Co., Bellefonte, Pa. At the same time **O. J. Skawden** was appointed assistant general manager.

Paul L. McCulloch, Jr. has been transferred to the Pittsburgh, Pa., district sales office where he will serve as sales engineer for the American Manganese Steel and Electro-Alloys divisions of the American Brake Shoe Co. He is replacing **M. A. Zeller** who has resigned from the company. Mr. McCulloch, formerly located in Rochester, N. Y., has been with Brake Shoe since 1945 when he started with the company as an apprentice. He attended both Columbia and Temple Universities.

Leo A. Kraemer, former superintendent of the by-product coke division of the Pittsburgh Steel Co., has been named operations engineer for the Engineering and Construction division of Koppers Co., Inc.

John Cullen has been appointed assistant superintendent of the yards, roads and transportation department at the Kaiser Steel plant, Fontana, Calif., and **J. L. Devine** has been named general yard master.

M. A. McAlpine is the new assistant superintendent of merchant mills at the Indiana Harbor, Ind., works of Youngstown Sheet and Tube Co. Mr. McAlpine moves up the ladder, succeeding **James McConnell** who recently was appointed superintendent of the mills, succeeding the late **Fred A. Schuessler.**

L. I. Stead has been appointed chief chemist for Chicago district plants of Youngstown Sheet and Tube Co. He succeeds Herbert McComb who died recently.

Edwin H. Keiper has been made chief service engineer of the Pennsylvania Crusher Co., Philadelphia, Pa. Mr. Keiper was chief design engineer at the time of his recent promotion.

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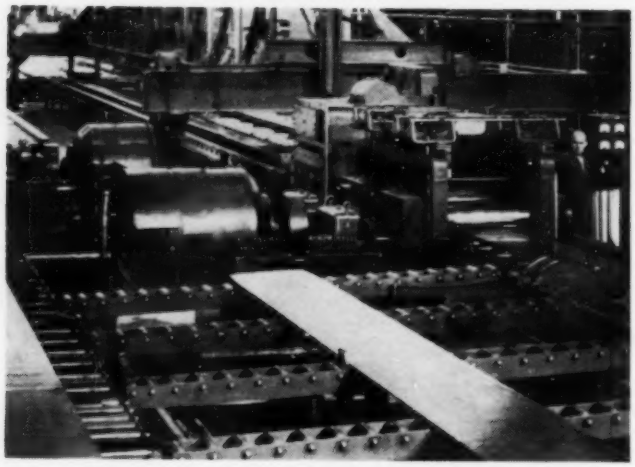

Eichleay is proud to have been called upon to mechanically install all the equipment in Scovill Mfg. Co.'s new ten million dollar Continuous Brass Mill.

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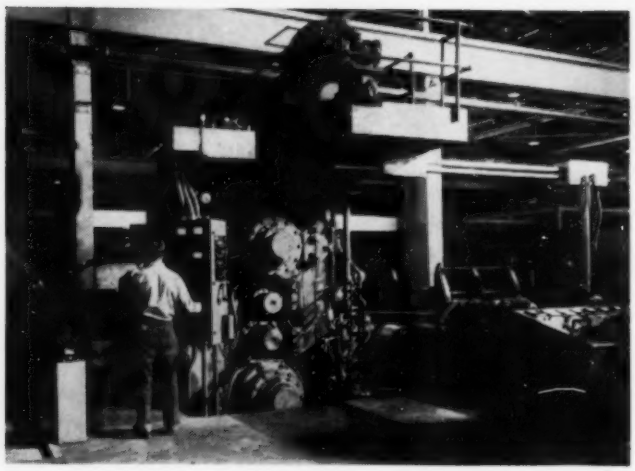

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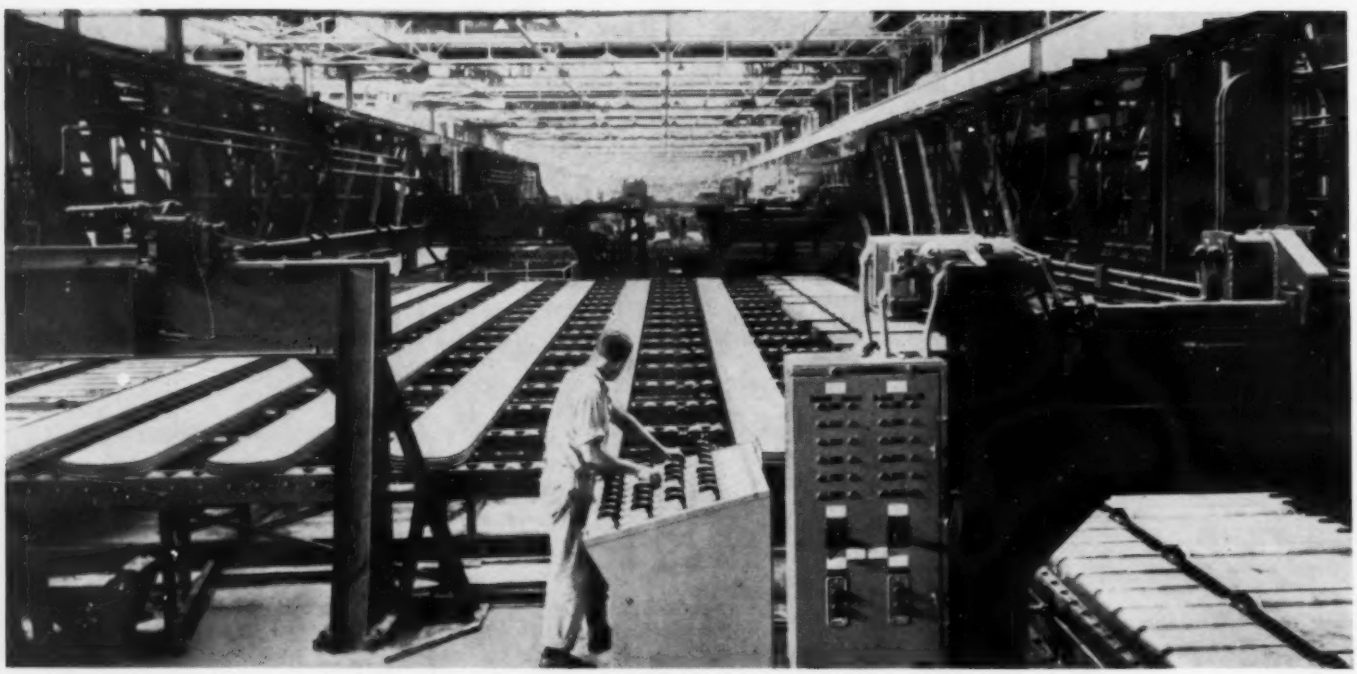

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... any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

(1) Carbon Cinder Notch

A new catalog section has been issued describing the carbon cinder notch lining and carbon cinder notch plugging. The two most economical and popular types of carbon cinder notch liners, the 180 degrees and the 240 degrees, are illustrated by dimensioned drawings and shown in place as units fully machined to fit snugly within the cooler casting. The method of plugging the cinder notch opening either with standard straight carbon brick or the one-piece tapered carbon plug is described in a step-by-step manner, with additional sectional drawings to illustrate. (M-8707). National Carbon Co., Inc.

(2) Carbon Splash Plates

A new catalog section is available describing the use of carbon in the construction of splash plates for the blast furnace. The principle advantages of carbon for such service are listed, with suggestions that greatly simplify splash plate use. The two methods of applying standard carbon shapes in splash plate construction are detailed. The first method consists of lining the conventional iron splash plate casting with "National" standard straight or arch carbon brick, while the second recommends the use of a one-piece carbon slab suspended within a welded steel frame. Both methods are illustrated. (M-8704). National Carbon Co., Inc.

(3) "Levelimeter" Instruments

A completely new 24-page illustrated catalog describing the line of "Levelimeter" instruments has just been published. These instruments indicate, measure and control liquid level and inter-face level. Variations in liquid level in weirs and flumes are utilized for measurement and control of large flow rates. Illustrated and described are magnetic tape-and-drum, electronically transmitting, ball-float, pneumatic and differential pressure units; V-notch weir and Parshall flume flowmeter instruments; and chemical service sight gauge glasses. (75). Fischer & Porter Co.

(4) Magnetic Crane Control

The many advantages of the Whiting simplified crane control system are thoroughly discussed in a new, fully illustrated 4-page bulletin. This method of control employes small master switches and solenoid starters instead of the old-style drum controllers or the over-engineered conventional magnetic control. It correlates trade-tested units such as lighter, easier operating masters, solenoid contactors and a fool-proof electrical circuit into an effective scheme of operation that protects the load and crane under all conditions. Customers have been consistently pleased with its low cost and maintenance-free operation. With this system, a full-vision cab may be used and, in this cab, the operator in a comfortable, seated position, controls all crane motions by finger-tip levers. (Unit 72). Whiting Corp.

(5) Rosslyn Metal

A pamphlet entitled "Rosslyn Metal for Heat Resisting Applications" has just been issued. Now being employed in many heavy industrial applications where high heat transfer is required as well as hard, corrosion resistant surfaces, the metal is a clad material consisting of a copper core, metallurgically bonded on both sides to stainless steel or Inconel. The metal has higher thermal conductivity than any other commercially available heat resisting material. Included in the new pamphlet is a study of the lateral conductivity of the metal and exhaustive tests concerning this exclusive feature of the new heat resistant metal. Oxidation resistance of the cladmetal in high temperature applications and design data are covered; as are also copper embrittlement tests and other significant engineering data. Physical constants at room temperature are stated. Also included is the workability of the new clad-metal with blanking, forming, spinning, mechanical finishing, annealing, pickling and welding covered. American Cladmetals Co.

(6) Mechanical Ventilation

Mechanical ventilation of industrial structures to remove air contaminated by fumes, dust or gases necessitates another function that is of equal importance—replacing, or making up, the air that has been exhausted from the building. How this can be accomplished efficiently and economically is described in a new illustrated brochure just published. Introduction of clean, fresh "tempered" makeup air into a factory structure, the bulletin explains, has two primary benefits: 1. Improvement of employee health and morale by elimination of foul air. 2. Balancing atmospheric pressure inside the building to increase the efficiency of combustion equipment and ventilating systems.

Regardless of the volume of air vented from a building by means of hoods above fume-producing operations, paint spray booth fans and other types of exhaust equipment, every cubic foot removed should be replaced by a cubic foot of fresh air. (520). Dravo Corp.

(7) Dry-Type Transformers

A versatile and flexible dry-type transformer for duty right at the load center is described in a new eight-page bulletin just released. Designed for hard service, the transformer is built in single-phase and three-phase types, both using "Fiberglas" and other Class B insulating materials. It has an all-welded steel case, sturdy lifting hooks, strong side frames, generous air ducts and clamp-type connectors. The bulletin also carries electrical and mechanical data on the transformers, which are built in sizes of 1½ kva and larger single phase, and 9 kva and larger, three phase. (61B6382A). Allis-Chalmers Mfg. Co.

(8) Automatic Compensation Meters

A new illustrated bulletin now

available explains how automatic compensation for pressure or temperature variations, or for both, are achieved in flow measurement of gases, liquids or other fluids with the Hagan compensated ring-balance meters. A schematic diagram shows how a corrected record is automatically and continuously produced — with the chart also showing uncorrected flow. A built-in integrator automatically totalizes the corrected flow. Another diagram illustrates installation of a pressure and temperature compensated Hagan Ring-Balance Flow Meter, while photographs show the meters as equipped for pressure compensation, temperature compensation, or both. (M-51). Hagan Corp.

(9) "How Rolls Are Made"

A 20-page booklet that describes and illustrates the numerous manufacturing processes required to produce a cast steel or cast iron roll which is used in the forming of steel has been prepared. "How Rolls Are Made" is said to be a picture-story of making rolls for industry. Twenty-two pictures, taken during normal operations are reproduced. The booklet is not a technical treatise, and every effort is made to explain roll making in "layman's language." The new literature describes the types of molds used to form cast iron and cast steel rolls. The dependence on open hearth and air furnaces is well disclosed. Tapping of furnaces; the pouring of molten metal into the bottom of the mold and its rise to the top, annealing, and roll finishing are comprehensively covered. Mackintosh-Hemphill Co.

(10) "Products and Processes"

. . a booklet published by Union Carbide and Carbon Corp., describes the principal activities of the five major corporation groups — alloys and metals; Chemicals; Electrodes, Carbons, and Batteries; Industrial Gases and Carbide; and Plastics. Short historical sketches trace the early years of some of the companies which are now a part of the corporation. Color views show a few of the major outgrowths of these pioneer developments.

Copies can be obtained by addressing Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, New York.

(11) Pumps

A new pump catalog is available. This catalog shows cut-away drawings of the six different types of "De Laval-IMO" rotary pumps, along with a brief description of each. The pump is designed to handle residual and distillate fuel oils, crude oils, all grades of lubricating oils, hydraulic oils, viscous fluids and liquids of similar characteristics. It is particularly well suited to oil burner, pressure lubrication and hydraulic pressure services. Capacities range from 0.5 to 1000 gpm for pressures to 500 psi and capacities to 150 gpm for pressures to 1500 psi. (LG). De Laval Steam Turbine Co.

(12) Bearings and Castings

A new catalog, "Bronze and Copper Bearings and Castings" has just been released. Illustrated with pictures and charts, this 28-page booklet gives physical properties and comparative specifications for 27 different bronze alloys and 5 aluminum and manganese bronzes. It contains an outline of the many applications of bronze. Sizes and weights of rough and machined "Tiger" Bronze bars are tabulated. Babbitt metals, their descriptions and uses, are also discussed and illustrated, and their various physical properties have been charted. This booklet describes the complete manufacturing facilities — from engineering conception to finished product — which National Bearing now has available for the manufacture of non-ferrous bearings and castings. Prominent space is devoted to illustrations of bearings and castings as made in the division's plant. National Bearing division, American Brake Shoe Co.

(13) Adjustable Speed Data

A series of five new publications on adjustable-speed have been announced as available. They are: "Adjustable Speed" (GEA-5334), "Adjustable-Speed ACA Motors" (GEA-4883A), "Speed Variator" (GEA-5335), "Electronic Speed Variator" (GEA-5336), "Thy-Mo-Trol Adjustable-Speed Drives" (GEA-5337). The first of these a 24-page booklet, presents a concise summary of the specific benefits which various branches of modern industry can expect from properly applied adjustable speed. It provides a convenient check list of points to consider in selecting an adjustable-speed drive and gives a clear picture of various packaged units — their range of application and performance features.

The other four publications contain complete descriptive and application data for the specific equipments involved, including their features, advantages, operating characteristics, and ratings. General Electric Co.

(14) Anhydrous Ferric Chloride

A simplified, concise manual on the properties, uses and methods of handling ferric chloride has been prepared by Pennsylvania Salt Manufacturing Co. for distribution among engineers, superintendents and operators of industries where the chemical is applicable. The 12-page leaflet lists and comments on the use of ferric chloride as ferric coagulates in the precipitation of sewage and sewage sludge conditioning. The unique solubility of Pennsalt anhydrous ferric chloride in a wide range of organic solvents makes it valuable as a catalyst in condensation, polymerization and chlorination reactions. The booklet contains information on Pennsalt's two commercial forms of the product, listing their characteristics and equipment recommended for their use. Prefacing the folder is the statement: "In commenting on these specific applications, it is our purpose to present interesting and pertinent information only, as these comments are not intended to be descriptive of any complete process." Pennsylvania Salt Mfg. Co.

(15) Gearmotors

Gearmotors are featured in a new 12-page book just released. Double and triple reduction units of new design, with motor mounted concentrically in line with the output shaft, are illustrated and described. Dimensions are shown for gearmotors having open drip-proof, splash-proof, totally enclosed and explosion-proof motor enclosures. The new book embodies a simplified catalog practice in that the previous three selection tables are replaced by a single selection table providing easier and more accurate selections of gearmotor size. (1815-A). Link-Belt Co.

(16) Liquid Level Controllers

A new bulletin on liquid level controllers has been issued. Both direct-connected and air actuated controllers are illustrated and de-

scribed in this 32-page catalog, with details of the special construction features and typical applications. Many schematic drawings, diagrams and photographs are included, with capacity charts, flow characteristics, pressure-temperature rating charts and dimensions. Featured also are Belfield pressure regulating and reducing valve disc-plugs, compression lubricator, stuffing box, angle valves and other auxiliaries. (48-I). Minneapolis-Honeywell Regulator Co., Belfield Valve Division.

(17) Silicone Grease

Silicone greases as ball bearing lubricants are described in two publications that have not previously been reviewed in the technical publications. Silicone Notes No. D-5 on "Dow Corning Silicone Greases" gives the properties, performance and uses of these heat stable and oxidation resistant silicone lubricants. Silicone Notes No. D-6, contains information on "How to Use DC 44 Silicone Grease in the Bearings of Electric Motors." It includes instructions for lubricating open and single shielded ball bearings and relubrication schedules based on the experience we have gained in developing and testing this exceptionally stable silicone grease. Dow Corning Corp.

(18) Cleaning Industrial Equipment

A general information bulletin is obtainable on a service for cleaning steam generating, heat exchange and other industrial equipment. Also included is information on pipe line cleaning and water well acidizing. Illustrations of the services are presented and the bulletin treats in detail the methods used to remove incrustations from the internal surfaces efficiently and economically with a minimum of downtime. Dowell, Inc.

(19) Pneumatic Conveying Systems

A folder is available on pneumatic conveying systems that can be designed to handle practically any solid materials. This particular system is essentially a batch unit and operates as a pressure system. The pressures used are moderate in comparison with other methods using high pressures or vacuum. (102). Convair Corp.

(20) Rubber-Lined Tanks

Tables showing acids which can be safely and economically handled by rubber linings and which give storage tank dimensions ranging from those which hold 225 gallons to 30,000 gal are a feature of the new six-page catalog section on rubber linings and rubber-lined tanks just published. The publication describes and pictures the Goodrich process for locking rubber to metal, discusses the materials used in various types of standard linings and recommended uses. Data on the comparative costs of acid storage in rubber-lined equipment versus the carboy is included. (9020). B. F. Goodrich Co.

(21) How to Choose a Supplier

The "twelve" basic considerations which should govern the selection of a supplier of steel castings — and other industrial suppliers as well — are reviewed in an interesting new 32-page brochure just issued. Producers of steel castings for machinery; construction; dredging, hydro-electric and heavy mill equipment; locomotives; gears, rolls and other parts, Continental has brought the knowledge and experience of years of service to the preparation of this helpful booklet. Continental Foundry & Machine Co.

(22) Fan Standards

The National Association of Fan Manufacturers, Inc., published NAFM Form X-12 entitled, "Physical Proportions of Commercial Fans," for the past several years as a service to architects, engineers and the general public. At the time the form was first distributed there were no recognized or acceptable size standards for centrifugal fans. In the absence of such standards the form represented a fair general comparison of physical proportions only of some types of centrifugal fans. To develop size standards for fans, the Association during the past ten years has studied the market to determine the number of fans required and the desirable interval between sizes. As a result of these surveys, size standards for the multiblade and non-overloading types of fans have been established and are now published in NAFM Bulletin 105. Recommended size standards for other types of fans have also been established for subsequent release. Therefore, Form X-12 is no longer needed and is withdrawn from further distribution and publication.

(23) Soot Blowing Systems

A 16-page bulletin describing automatic-sequential power-operated soot blowing systems has been published. Operating procedures are discussed in detail, and ten typical installations are shown diagrammatically. (483). Vulcan Soot Blower Corp.

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50	BEDFORD FOUNDRY AND MACHINE CO.		Catalog describing Bedford cranes with capacities from 5 to 150 tons.
51	BROWNING AND CO., INC., VICTOR R.	BULLETIN "S"	Bulletin on Browning mill type cranes.
52	BUSSMANN MANUFACTURING CO.		Complete facts available about Fusetron dual-element fuses.
53	CLARK CONTROLLER CO.	BULLETINS 7700, 7400 and 7322	Covers Clark heavy duty contactors, overload protection and thermal overload relays.
54	CRANE CO.	CIRCULAR 320	A circular on the Crane corrosion-resistant line.
55	EICHLEAY CORP.		A new illustrated booklet is available showing all types of erection, installations, etc.
56	ELECTRIC CONTROLLER & MFG. CO.	BULLETIN 942	Describes tab-weld plate resistors for crane and mill auxiliary control.
57	FARVAL CORP.	BULLETIN 25	Full description of Farval's centralized lubrication.
58	FAWICK AIRFLEX CO., INC.	BULLETIN 300	Complete engineering information on Fawick clutches.
59	FURNACE ENGINEERS, INC.		Bulletin available telling about Furnace Engineers' service complete from plan to production.
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64	KOPPERS CO., INC., FAST'S COUPLING DEPT.		Bulletin shows how Fast's couplings operate and describes the many sizes and types.
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70	NATIONAL-ERIE CORP.	BULLETIN 9	Full technical details available on Neloy and Neloy-Molybdenum gears and castings.
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76	RELIANCE ELECTRIC AND ENGINEERING CO.	BULLETIN C-404	Contains facts on proved-in service advantages of Reliance gear motors.
77	SQUARE D CO.	BULLETIN 3100	Describes Square D's new safety switches.
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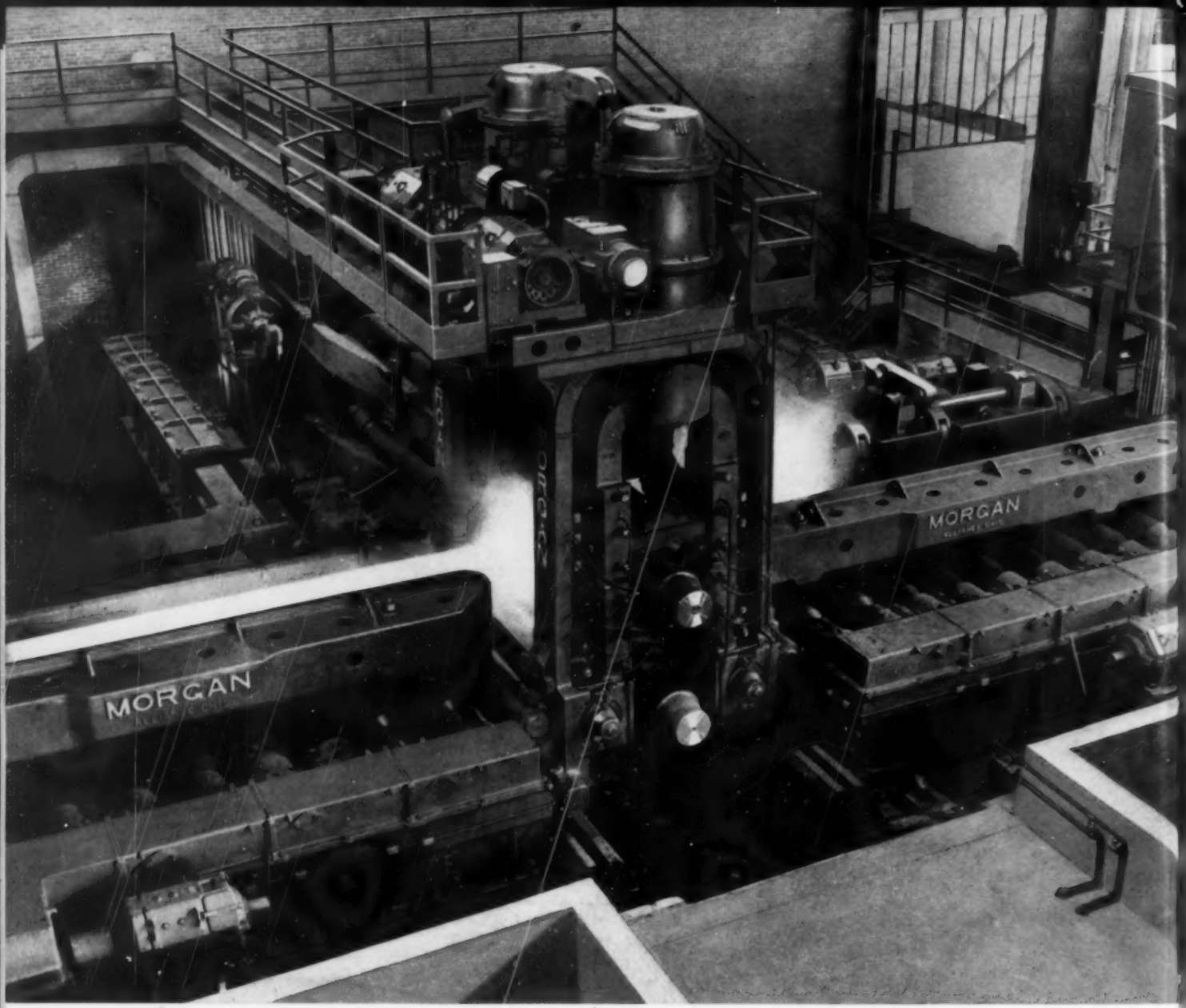

Morgan 40″ — 2 High Reversing Blooming Mill direct connected to two 3000 Hp. 40/100 Rpm. motors. Top roll and both spindles are hydraulically balanced by individual cylinders connected to an air hydraulic system. Speeds of motor driven screw down, feed rollers, mill tables and manipulator are regulated by variable voltage control.

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Equipment News...

SHEAR LINE DEVELOPMENT FLATTENS AND CUTS COIL STOCK AT 300 FPM

▲ Coil stock can be flattened and cut to any length at approximately 300 fpm on a new, simple, moderately priced shear line developed by the E. W. Bliss Co. Designed for moderate production in steel, brass and copper mills, warehouses and fabricating plants, the complete line consists of a coil stop, payoff reel, roller leveller, looping table, upcut shear, gage table and automatic gage unit, oiling unit, pinch rolls and sheet piler.

The newly designed and simplified upcut shear features an extremely rigid, solid slab one piece frame, bored to accommodate the self-aligning type antifriction bearings for the eccentric shaft. The lower knife head slides on flat bronze ways on the cutting (or knife) side of the head, and is backed up by a 45 degree bronze slide member on each side. This arrangement simplifies the problem of adjusting for wear in the slides, since only one adjustment compensates for both side and end wear. This arrangement also reduces friction on the lower knife head, giving the shear a "snappier" action than can be obtained by conventional methods of slide mounting. The bottom knife stroke is 4 in.

The shear is operated through a patented Bliss air clutch with built-in flywheel and integral brake, actuated by a 4-way solenoid valve. All bearings in this unit are antifriction. Drive is by multi-V-belts from a continuously running motor to flywheel of clutch mechanism, and from clutch to shear eccentric shaft by completely enclosed helical gears. "Turnover" speed of the shear is 60 cuts per minute.

The shear gage, hung on rollers from a beam located over the gage table, is moved to position manually for any length of cut and locked securely by means of wedge clamps and handwheel. The gage consists essentially of a spring balanced stop bar, mounted to sweep away from the end of the strip when being raised. This arrangement prevents damage to the cut end of strip.

The gage bar is raised through a toggle arrangement by a solenoid coil. It is positively locked in the gaging position by the toggle action, making it impossible for the strip to move the gage bar and cause a miscut.

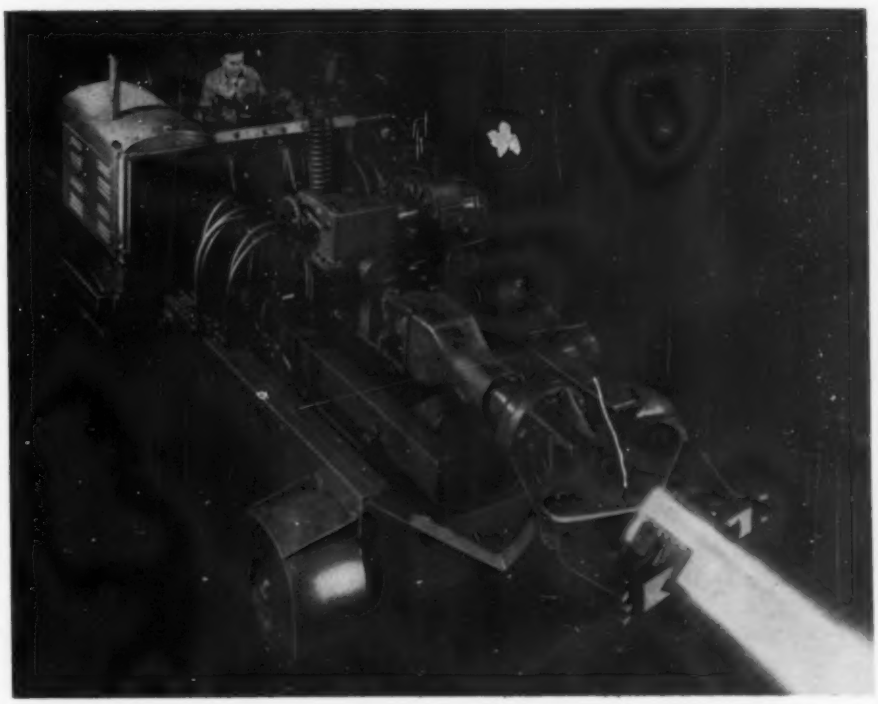
The shear is tripped by a limit switch, actuated by a trigger mounted on the front face of the gage bar. After a cut is made, the gage bar is automatically raised by actuating the solenoid coil through a limit switch mounted on the eccentric shaft of the shear, allowing the cut sheet to proceed under the bar. A second limit switch on the shear eccentric shaft deactivates the clutch and activates the brake through a solenoid valve, stopping the shear. The shear gage solenoid is then deactivated allowing the gage arm to drop by gravity until it rides the sheet (a small fiber roller is mounted on the bottom of gage bar to prevent scratching of the sheet). When the end of the sheet is reached, the gage bar drops to its full lowered position, locking the toggle by gravity action. It is then ready for the next cut.

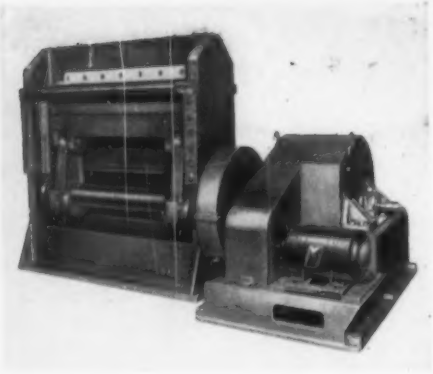
Space is provided between sheets for dropping the gage bar by running the shear exit conveyor approximately 10 per cent faster than the shear entry conveyor.

A time saving feature of the line is the newly designed hydraulic piler, which consists of a platen mounted on two mechanically synchronized hydraulic cylinders. This platen is

33,000 LB MANIPULATOR SHIPPED TO ITALY

A new auto-floor manipulator has just been completed by the Edgar E. Brosius Co., Inc., for the Nazionale Cogne Steel Plant at Torino, Italy. Because of its tremendous size special permission had to be granted to transport it over the Pennsylvania and New Jersey highway system to the docks on the Hudson River. It weighs 33,000 lb and has a capacity to handle a 10,000 lb bloom or forging blank in its continuous rotating tongs. In addition to self-propulsion and the ability to turn on its own wheelbase, the machine has six additional motions, namely, a two foot lateral movement of the peel, raising and lowering of the peel in a horizontal position, tilting the front or rear of the peel independently, tongs grip, and continuous rotation of the tongs. All movements, except travel over the floor, including steering are actuated hydraulically. This particular machine is diesel-engine powered.





A time saving feature of the new shear line is the newly designed hydraulic piler.

intermittently lowered as the sheets are piled between universally adjustable side and end guides, suspended from overhead on antifriction equipped wheels or rollers and arranged for positive locking in any selected position. When the desired height of pile is reached, the piler is lowered to its extreme bottom position, allowing the platen to straddle permanently located gravity rollers. The pile is deposited on these rollers and automatically discharged under the side guides for storage at the side of the piler.

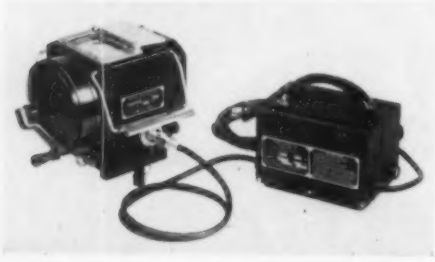
DUAL-OPERATED A-C UNIT AVAILABLE FOR TESTING

▲ The familiar hand-cranked "Meg" type of "Megger" is now available in a combination hand-crank and rectifier-operated set. It consists of the "Meg" type constant-pressure test set and a separate rectifier which supplies 500 volts d-c from any 115 volts a-c, 60 cycles outlet. One cord from the hand-crank instrument and another from the rectifier to an a-c outlet eliminates hand operation.

This new dual-operated instrument, manufactured by James W. Biddle Co., will have its most important application in communications and in extensive cable wiring and control installations where a great many tests are to be made, and where an a-c outlet is readily available. It will prove a boon where continuous operation of the instrument is desired, as in the case of observing dielectric absorption effects in various types of electrical equipment. Many laboratory investigations will be benefited by the power supply unit.

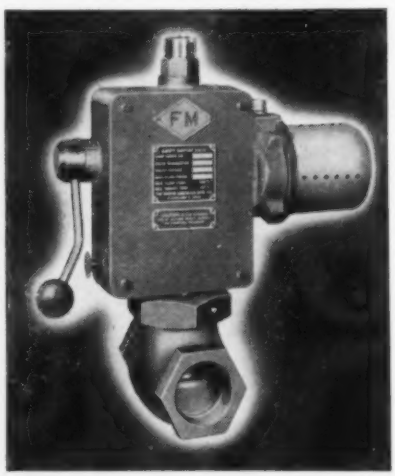
The availability of the hand-cranked instrument, without the rectifier, makes it particularly attractive to those who would use it in the field. Railway signal engineers and traveling inspectors, and testmen in telephone, telegraph and power work recognize its advantages.

An application of this instrument is in cable wiring and control.



SAFETY SHUTOFF VALVE FOR INDUSTRIAL FURNACES

▲ The North American Manufacturing Co. has recently added to its production line a new Associated Factory mutual Approved valve known as the Series "21" safety shutoff valve. Designed for the protection of



industrial furnaces against dangerous accumulations of gaseous or liquid fuels in the event of a power failure, this valve stops the flow of any gas or liquid instantly when the current to its solenoid is interrupted. When the power is restored, the valve remains closed until the trouble is corrected, at which time the valve is reset manually.

Any number of switches wired in series with the solenoid can protect the installation against explosion hazards resulting from failure of air pressure, gas or oil pressure, etc., in addition to general power failure, or the valve may be tripped closed manually if desired. It cannot be wedged or propped open with power off since the resetting handle is independent of the valve stem.

Featuring a globe type, soft-seating valve the Series "21" safety shutoff valve can be had with all iron body and internals for use with corrosive gases or liquids. They can be furnished with chain reset wheels for overhead mounting and with auxiliary switches for independently powered alarm systems. Available in sizes from ¾ in. through 6 in. they may be equipped with solenoids of 110, 220, 440 volts and 60, 50 and 25 cycles.

BONDED METAL HAS HIGH THERMAL CONDUCTIVITY

▲ Faced with metal problems never encountered before, engineers in the field of jet power are counting on the thermal properties of Rosslyn metal to relieve metal difficulties met at elevated temperatures. Rosslyn metal sheet, produced by American Cladmetals Co., consists of a copper core metallurgically bonded permanently on both sides with surfaces of stainless heat resistant steel or Inconel.

The sudden surge of high heats in jet power plants has too often caused hot spots resulting in cracking and buckling of heat resistant metals used up to now in aircrafts. Engineers pioneering in the new field of jet power welcome the advent of this new metal with properties capable of dissipating troublesome high temperatures which are conducted by the copper core away from hot spots to equalize conditions over the entire power plant unit.

The hard, durable heat resistant and corrosion resistant high chrome-nickel steels and Inconel, when used in the new metal with its copper core, but only so used, provide far better thermal conductivity than any other heat resisting materials. At the same time they offer excellent structural and non-oxidizing properties.

Those working with the metal in the jet, gas turbine, and rocket type power fields anticipate improved performance, and conservation of such strategic metals as columbium and cobalt, high on the critical lists. Development work using Rosslyn metal, which started in this field in 1948, is now progressing with acceleration.

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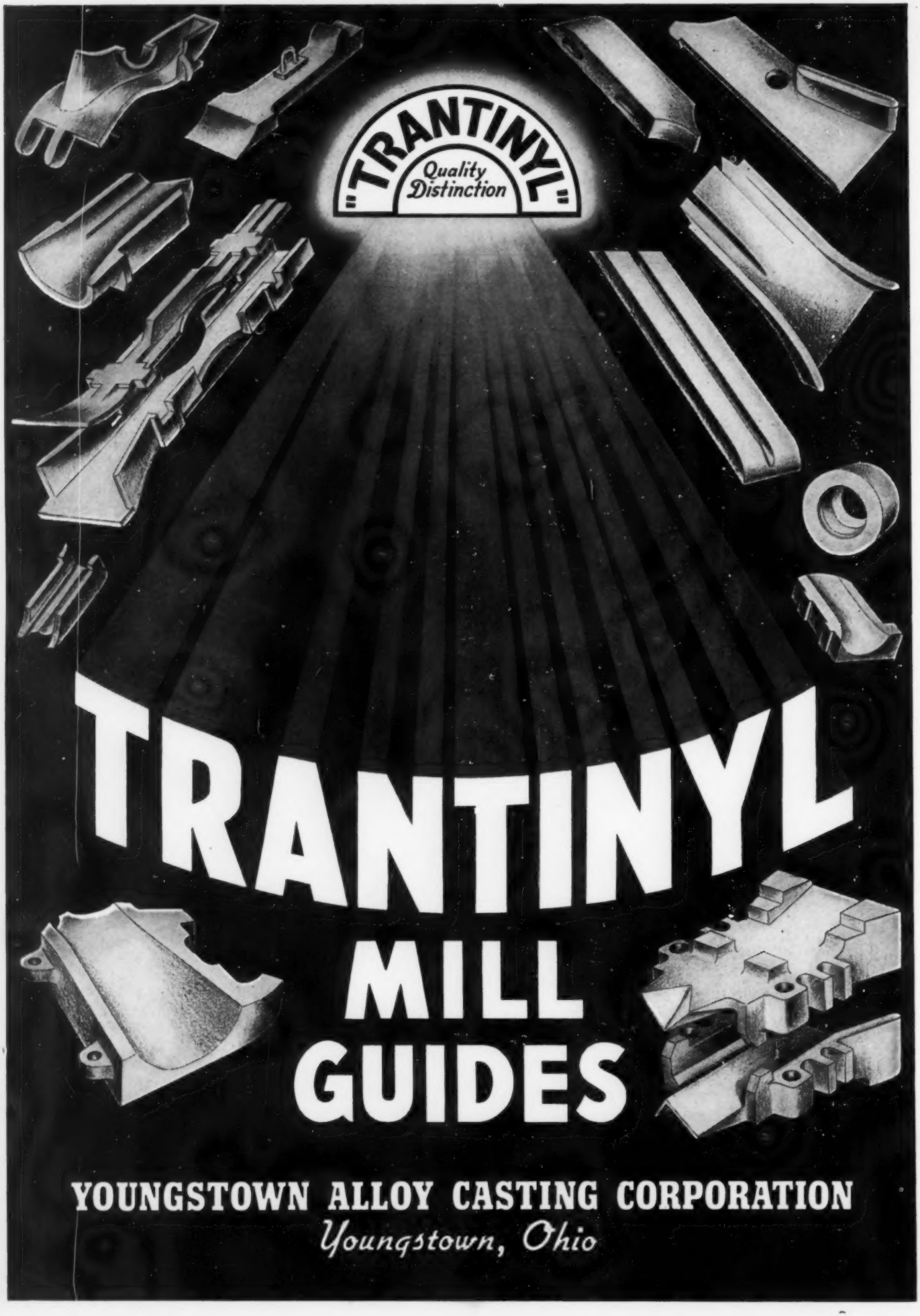
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For a full description, write for Bulletin No. 25. The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

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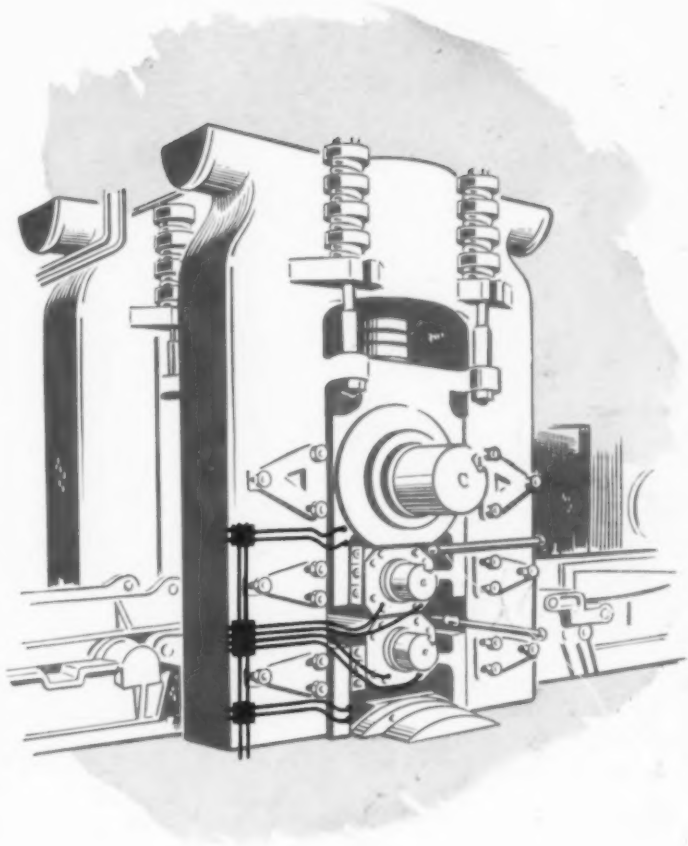
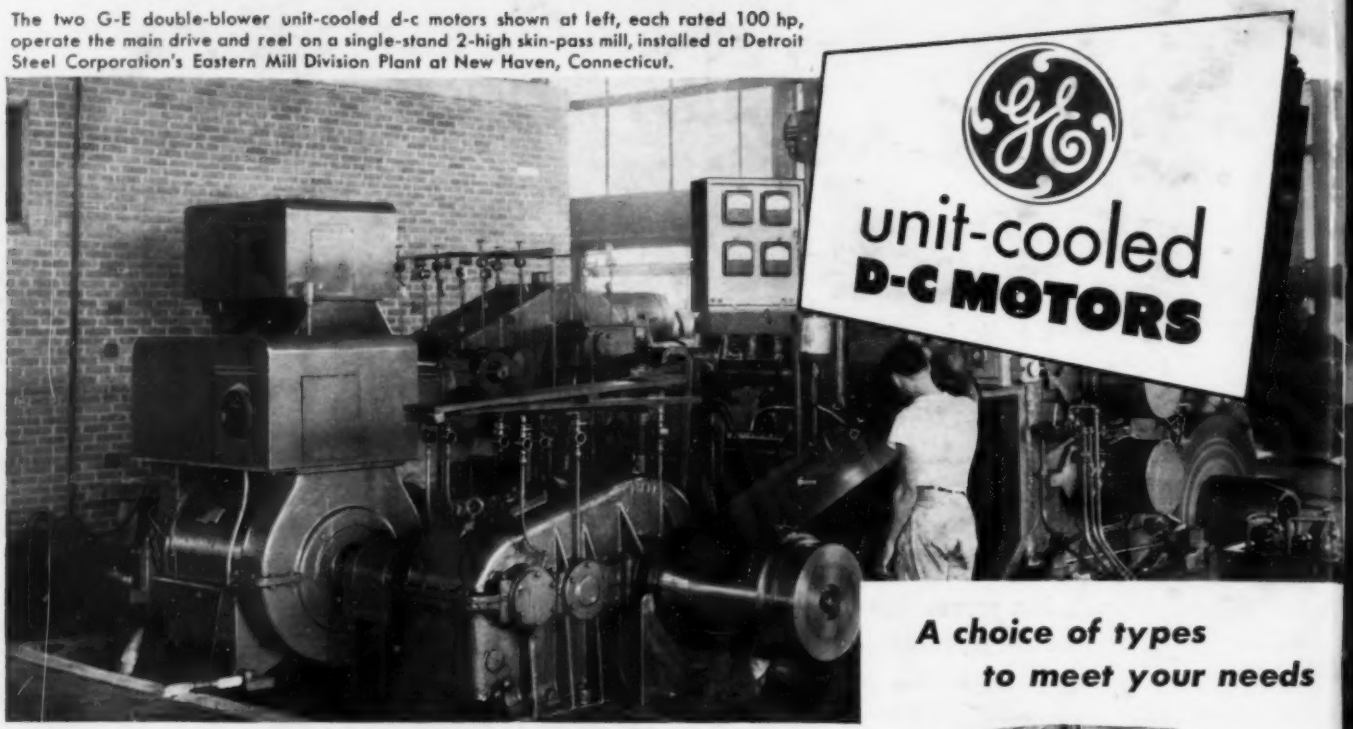


FARVAL—*Studies in Centralized Lubrication* No. 113

The two G-E double-blower unit-cooled d-c motors shown at left, each rated 100 hp, operate the main drive and reel on a single-stand 2-high skin-pass mill, installed at Detroit Steel Corporation's Eastern Mill Division Plant at New Haven, Connecticut.



unit-cooled D-C MOTORS

self-protected...to cut installation costs!

In dusty, dirty or oil-laden atmospheres—where open motors can't take it without special protection—you can cut installation time and costs to a minimum with General Electric totally-enclosed unit-cooled d-c motors. Motor and unit cooler, completely factory-assembled as a unit, come to you ready to install. They need no specially-built motor room, no piping, ductwork, coolant, filters or pressurized air supply. You simplify plant layout, save extra equipment cost!

These better-protected, better-cooled G-E motors—available in ratings from 15 to 200 hp—also

. . . **minimize inspection shutdowns!** Windings, brushes and brush rigging are kept clean at all times because harmful air-borne materials can't get into the motor's internal ventilating air.

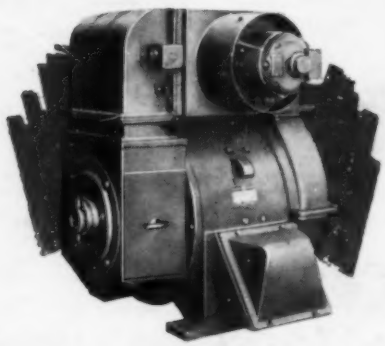
. . . **reduce power cost!** Because motor heat is rapidly dissipated, power consumption is less, especially in wide-range adjustable-speed motors.

. . . **simplify maintenance!** Large openings in the commutator end shield make it easy to get at commutator, brushes, and brush rigging.

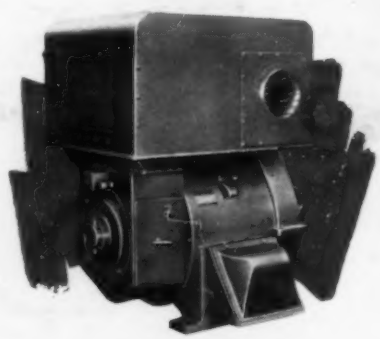
. . . **save mounting time!** Interchanging of motors to meet changing mill conditions takes less time because G-E totally-enclosed motors have the same mounting dimensions as G-E open motors of the same ratings.

Get the whole story! Ask your G-E representative how these sturdy, protected motors can help trim operating costs in *your* mill, or send for Bulletin GEA-4469. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

A choice of types to meet your needs



In single-blower type— for constant and adjustable speed operation at normal speed—unit cooler circulates internal air with a shaft-driven fan. External air is forced through alternate air passages by a separate motor-driven blower.



New double-blower type— can be operated continuously without harmful overheating, even at very low speeds. A single Tri-Clad® auxiliary induction motor drives both blowers, one for internal motor air, the other for external cooling air.

GENERAL ELECTRIC

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